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BASIC GAS CHLORINATION WORKSHOP

1974

Ministry of the Environment

Ontario

The Honourable
William G. Newman,
Minister

Everett Biggs,
Deputy Minister

BASIC GAS
CHLORINATION WORKSHOP
MANUAL

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include:

Activated Sludge Process
Analyses and Interpretation Workshop

Basic Sewage Treatment Operation Course
Basic Water Treatment Operation Course

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Behavioral Objective Approach to Training (BOAT)

GENERAL

The behavioral (performance) objectives are designed to tell the operator, or trainee, what he will have to know and what he will have to do for successful completion of the workshop. At the same time, it tells the instructor what he will *have* to teach, describe, or demonstrate so that the trainee will reach his goal (and not what he would *like* to teach).

This approach to teaching is based on the Behavioral Objective Approach to Training (BOAT).

WHAT IS BOAT?

BOAT is a method of training which states briefly and clearly what the performance of a trainee should be upon completion of a learning period, such as a workshop. The objectives are set down at the beginning of each topic so that both the trainee and instructor know what must be done. To verify successful completion, tests are given under conditions as similar as possible to actual on-the-job working conditions. If the test requires an actual "hands-on" type of performance, the trainee will be tested accordingly.

Objectives serve other purposes as well: they enable the operator to determine how well he is doing on a particular topic, and they also enable the instructor to organize his time for maximum efficiency.

LEVEL OF COMPETENCE

Each topic has stated objectives which must be presented to the trainee at the workshop. To fulfill the Basic Gas Chlorination Workshop requirements, the trainee must attain a minimum average of 70% on all topics (written, oral and hands-on testing).

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APPENDIX (continued)

INTRODUCTION

This book has been written for operators to use as a home study manual, especially by those unable to attend a workshop. The workshops cover five days at the Ministry of the Environment Laboratories Lecture Hall and Wallace & Tiernan Division, PENNWALT Canada Limited, about half a day is reserved for theory, half a day for lab testing, one day for safety, and three days for equipment. The emphasis is on the operation and preventive maintenance of gas chlorination equipment.

The principal reason for developing a gas chlorination workshop is the great importance of chlorination in maintaining a desirable water quality at water and wastewater treatment plants. Many operators have a fear of chlorine gas, resulting in a reluctance to attempt preventive maintenance on chlorination equipment. As a consequence, interruptions can occur in the chlorination of water and wastewater at treatment plants.

These manuals and workshops are designed to teach the operator the necessary knowledge and skill in safety and preventive (some corrective) maintenance. Basic theory and chlorine residual testing are included.

The objectives are clearly indicated at the beginning of each topic, and tell the operator exactly what he should know or do in relation to that topic. The operator is expected to reach a minimum level of competence of 70% for the workshop. Testing will depend on the particular objectives; there will be written tests, and there will also be practical, or hands-on testing with actual equipment available.

February, 1974

Jacques L. Bourque, Supervisor
Training & Licensing Section

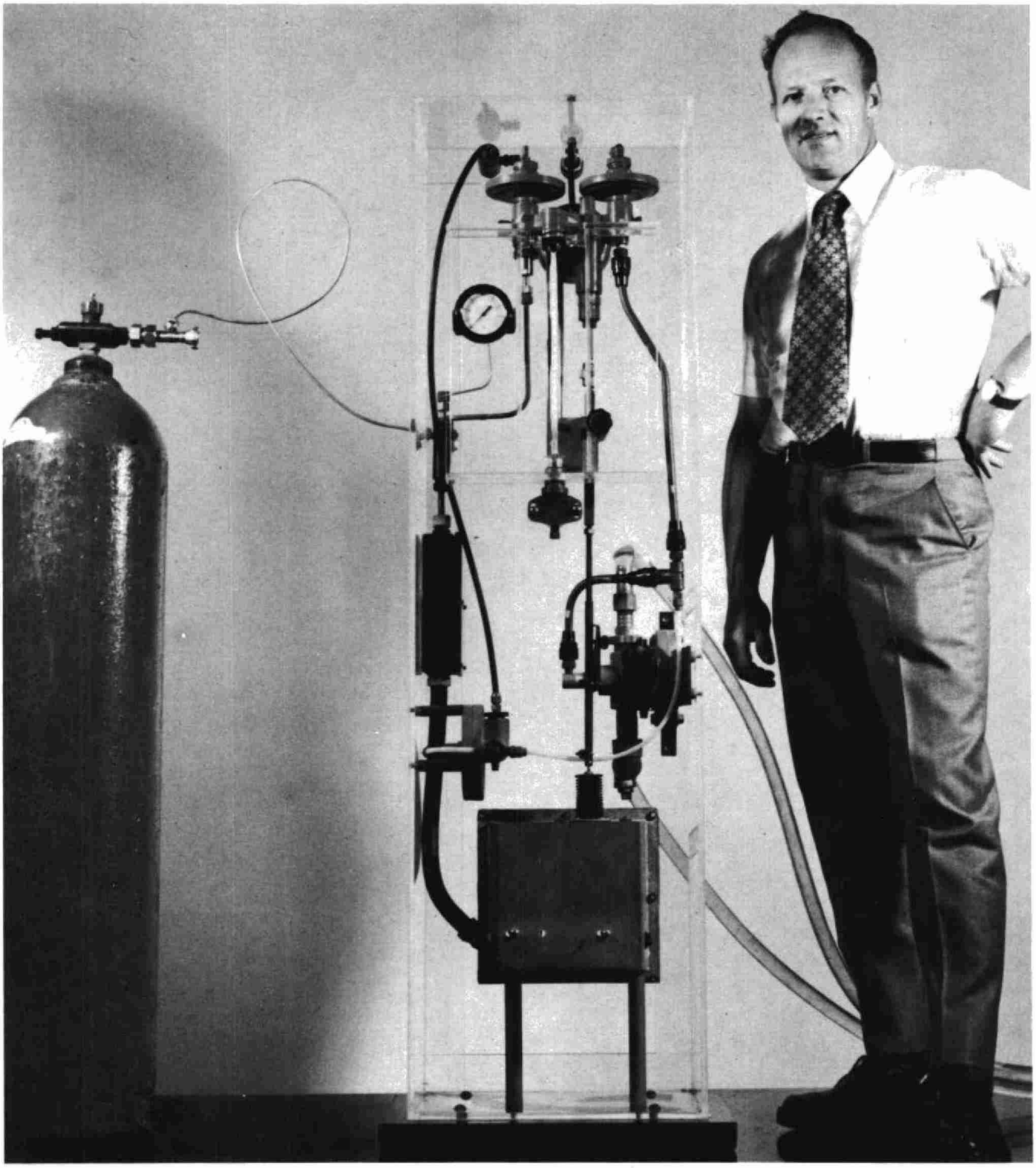


Fig. 1 Front view of gas chlorinator (housed in plexiglass) used during workshops.

SUBJECT:

CHLORINATION THEORY

TOPIC: 1

PURPOSES OF CHLORINATION AND QUALITY CONTROL

OBJECTIVES:

Trainee will be able to describe and/or list:

1. The different purposes of chlorination;
2. General water quality considerations;
3. Ministry of the Environment chlorination objectives.

PRINCIPAL PURPOSE

The principal purpose of chlorination is *DISINFECTION* - killing bacteria and viruses harmful to man. The chlorine does not kill the bacteria and viruses directly but mainly by forming hypochlorous acid (free residual chlorination) when the chlorine gas and the water are mixed together in the chlorinator. At the same time, an equal amount of hydrochloric acid is produced which reacts with the alkalinity in the water. *In case of very heavy chlorine dosages, the acid can seriously reduce the pH and cause corrosion.*

OTHER PURPOSES OF CHLORINATION include:

Control of taste and odour problems when free or combined residual chlorination is practiced.

Oxidation of manganese, nitrites, and ammonia, or the destruction of phenols and the removal of algae and slime growth by free residual chlorination.

If too little chlorine is added, the taste and odour problems may become severe.

When chlorine is added to water for disinfection, it reacts with any organic and inorganic materials that might be present. Such reactions complicate the disinfection process because the chlorine demand of these materials must be satisfied as well as those associated with the disinfection reactions.

CONTACT TIME

Contact time is the amount of time required to allow *complete reaction* of the chlorine with the foreign matter in the water and also to kill bacteria and viruses present in the water supply. *A minimum contact time of 15 minutes is recommended.*

Always add chlorine at a point where complete mixing will occur.

GENERAL WATER QUALITY CONSIDERATIONS

To chlorinate, consider the amount of pollution in each water supply.

For example, add one part per million (ppm) hypochlorous acid (chlorine) to a chemically clean water like Lake Superior, which contains some bacteria but no ammonia or proteins. The chlorine will kill all the bacteria in seconds.

On the other hand, add one part per million (ppm) chlorine to a chemically dirty water like the Grand River, and the hypochlorous acid will react with ammonia and proteins from sewage, industrial wastes, algae and land drainage to form chloramines (compounds of organic or inorganic nitrogen and chlorine). These chloramines can take hours to kill the same number of bacteria that are killed in seconds by free residual chlorination (hypochlorous acid). Furthermore, the

chlorine can react with other materials in the water, such as iron and nonprotein organic matter, and be completely consumed without disinfecting anything.

So the amount and type of chlorine residual used is controlled by:

(a) degree of chemical and bacterial pollution,

(b) contact time in the plant beginning with the application of chlorine to the moment it reaches the first consumer.

MINISTRY OF THE ENVIRONMENT CHLORINATION OBJECTIVES

The Ministry of the Environment has set up minimum objectives (see *BULLETIN 65-W-4* in Appendix) for chlorination of public water supplies. These objectives are set up on the broadest concept to protect the maximum number of consumers at any one time. Occasionally these minimum objectives will have to be *exceeded* in water plant operating practice and a higher residual may have to be used.

An operator can follow the guidelines in meeting the minimum objectives, but still produce a water contaminated with coliform bacteria. In these cases, public health is in danger. Immediate changes in the chlorination program must be made, such as:

(a) increase the chlorine residual,

(b) change the type of residual,

(c) change the point or points of application,

(d) increase the contact time between point of application and the first consumer.

The water utility is an industry producing a saleable, potable product. As such, certain quality control measures are required. One of these is the chlorine residual analyser and recorder. This equipment must be kept in proper operating order. The record of chlorine residual provides the operator with positive proof of performance.

The chlorine residual must be checked and recorded at least once every 8-hour shift. The residual is maintained at or above the minimum required for the plant. These requirements are set by the Ministry of the Environment Regional Engineer (Sanitary Engineering Branch) who uses *Bulletin 65-W-4* as a guide.

pH AND ITS EFFECT ON CHLORINATION

The pH of a water is an indication of its acidity or alkalinity. It can be lowered to corrosive levels by the addition of chlorine, alum and other coagulants. In some cases, the pH of the raw water may already be too low. Regardless of the cause of low pH, it should be corrected to prevent corrosion by adding an appropriate alkali before the

water goes to the distribution system. *All chlorine compounds are most effective in bacteria and virus destruction at low pH.* Any pH correction upwards (above 7.5) should be done *after* the chlorine has done its work.

IMPORTANCE OF TURBIDITY REMOVAL IN WATER TREATMENT

In the chlorination of water, no mention is made of the effects of turbidity because it is assumed that the water meets the turbidity requirements of 1 unit maximum. However, *bacteria can be concealed within the turbidity particles and be immune to the effects of chlorination.* Turbidity removal is usually considered as improving the appearance or clarity of the water and preventing the accumulation of mud in the distribution system. However, turbidity removal is very important in that it eliminates chance bacteria contamination as well.

GENERAL WASTEWATER QUALITY CONSIDERATIONS

The main reason for using chlorine in sewage treatment is to kill germs. The bacteria in sewage can be divided into two classes: useful and harmful. The useful types are the organisms which live on dead or decaying organic matter. The harmful types (germs) are the *pathogens*, organisms which cause disease such as typhoid fever, gastroenteritis, cholera, and dysentery. *The principal purpose of chlorination is to destroy harmful bacteria.*

In sewage treatment plants, chlorine may be applied to the raw sewage (in a sewer, pump well or inlet channel at the plant) and/or the treated effluent. Applying chlorine to the influent will control odour throughout the plant as well as disinfect.

Chlorine is a surface active agent. This means that the bacteria hidden within a dirt particle will not be killed by the chlorine. Therefore, chlorine should be added for disinfection purposes at a point *after* solids removal (effluent of sedimentation tanks). In addition, after solids removal it will take less chlorine to achieve the required total chlorine residual of 0.5 ppm after a 15-minute contact period. A chlorine contact chamber (properly baffled) is normally used to provide the minimum contact period.

SUBJECT:

CHLORINATION THEORY

TOPIC: 2

TYPES OF CHLORINE FEEDERS AND THEIR USAGE

OBJECTIVES:

Trainee will be able to:

1. Identify the basic types of chlorine feeders;
2. Describe their uses.

TYPES OF CHLORINE FEEDERS

The three basic types of chlorine feeders (or chlorinators) are:

1. Dry (direct) feed gas chlorinators;
2. Solution feed gas chlorinators;
3. Hypochlorinators (these use chlorine compounds).

USES

1. *Dry* (direct) *feed* gas chlorinators are used to apply dry chlorine gas to sewage. They are used only where water under pressure is not available. Their use requires care in selecting the point of application.

2. *Solution feed* gas chlorinators are used to mix an auxiliary supply of water with chlorine gas. The mixture or solution is then applied to the water or the sewage to be treated. Vacuum-type chlorinators are the most preferred.

3. *Hypochlorinators* are used

   (a) for relatively low flows,

   (b) where chlorine gas cannot be fed for safety reasons,

   (c) where the chlorine requirement is small,

   (d) due to lack of water pressure.

Installation costs are lower than for gas chlorinators, but operating costs are higher. Generally, hypochlorinators are diaphragm-type pumps.

SUBJECT:

CHLORINATION THEORY

TOPIC: 3

CONTROL SYSTEMS

OBJECTIVES:

Trainee will be able to:

1. Name the types of chlorine control systems;

2. Describe the chlorine control systems.

TYPES OF CONTROL SYSTEMS

The chlorine control systems available include:

1. Manual system;
2. Flow proportional or open loop control;
3. Direct residual or closed loop control;
4. Compound loop control.

1. MANUAL SYSTEM

   (a) The rate of feed is varied by hand.

   (b) It is only suitable at points: (i) where flow of sewage or water to be treated is constant, (ii) where the flow rate is changed manually (e.g. when starting a second pump), at which time chlorination feed can be adjusted to the new flow.

2. FLOW PROPORTIONAL OR OPEN LOOP CONTROL (see Figs. 3-2, 3-3)

   In the flow proportional or open loop control system:

   (a) an adjustment is made in accordance with a command signal from the flow meter or pump starter. Response is *assumed* to be correct.

   (b) any signal from a primary measuring device (orifice, venturi, etc.) can be fed directly or converted to proper form by a *transducer* to allow electric or pneumatic positioning of chlorinator control units.

3. DIRECT RESIDUAL OR CLOSED LOOP CONTROL (see Fig. 3-1)

The direct residual or closed loop control system operates as follows:

(a) a sample of chlorinated water is continuously withdrawn downstream from point of chlorination and analysed.

(b) the recorder compares the *measured* residual with the *desired* or set residual to see if the chlorine feed rate should be increased or decreased. It then sends a signal to the chlorinator control device to make the change.

(c) types of signals used include:

(i) an electric signal;
(ii) a pneumatic signal;
(iii) a vacuum signal.

NOTE:

Why is it called a closed loop?

Measurement of end result is made and information is fed back to the chlorinator control for comparison with control set point.

4. <u>COMPOUND LOOP CONTROL</u> (see Fig. 3-4)

The compound loop control system is a combination of open loop and closed loop systems. When flow increases, the chlorinator adds the correct amount of chlorine to keep the present dosage level. A sample is withdrawn downstream and analysed to determine if chlorine demand has changed. If so, information is relayed back to the chlorinator and correction in dosage is made according to the new chlorine demand.

NOTE:

When are each of the above systems used?

1. *When flow remains constant, but chlorine requirements do not, direct residual control is used.*

2. *When flow varies and chlorine requirements remain constant, flow proportional or open loop chlorination control is used.*

3. *When both flow and chlorine requirements may vary, compound loop chlorination control is used to maintain desired residual of chlorine in water.*

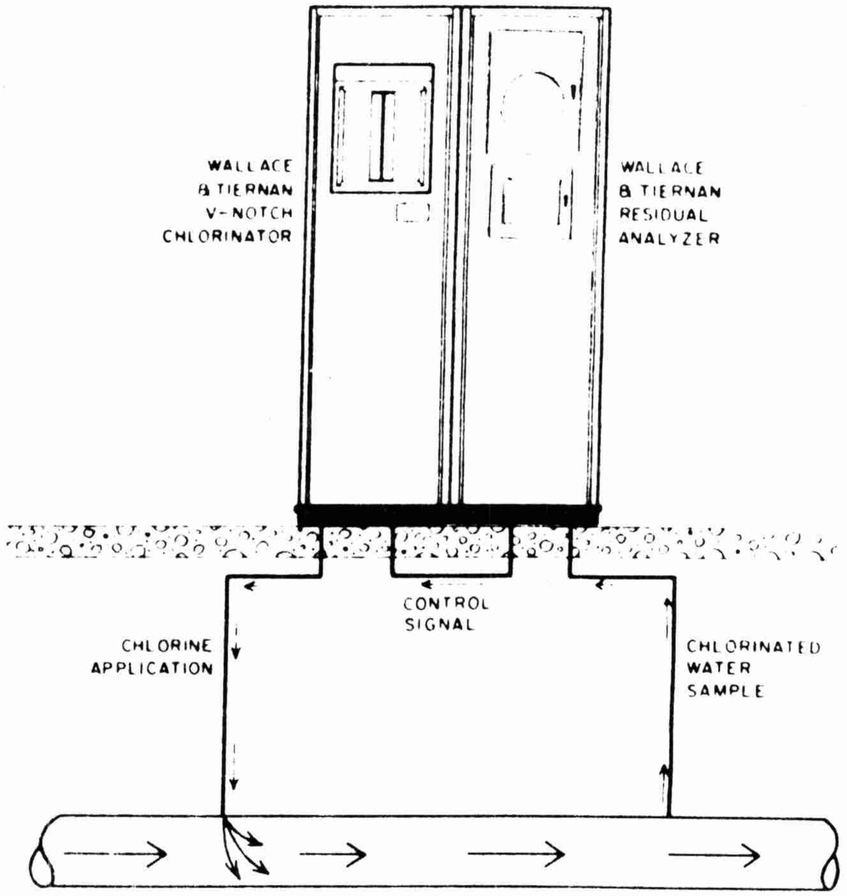


FIG. 3-1. DIRECT RESIDUAL CONTROL. (Closed - loop).

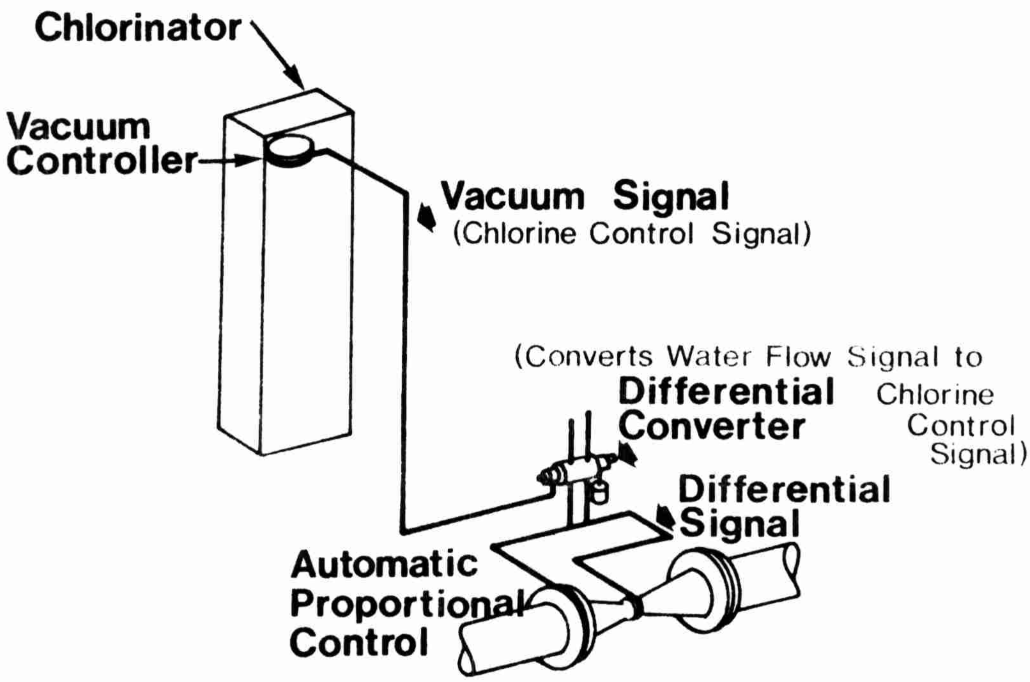


Fig.3-2 Open Loop Control Chlorination

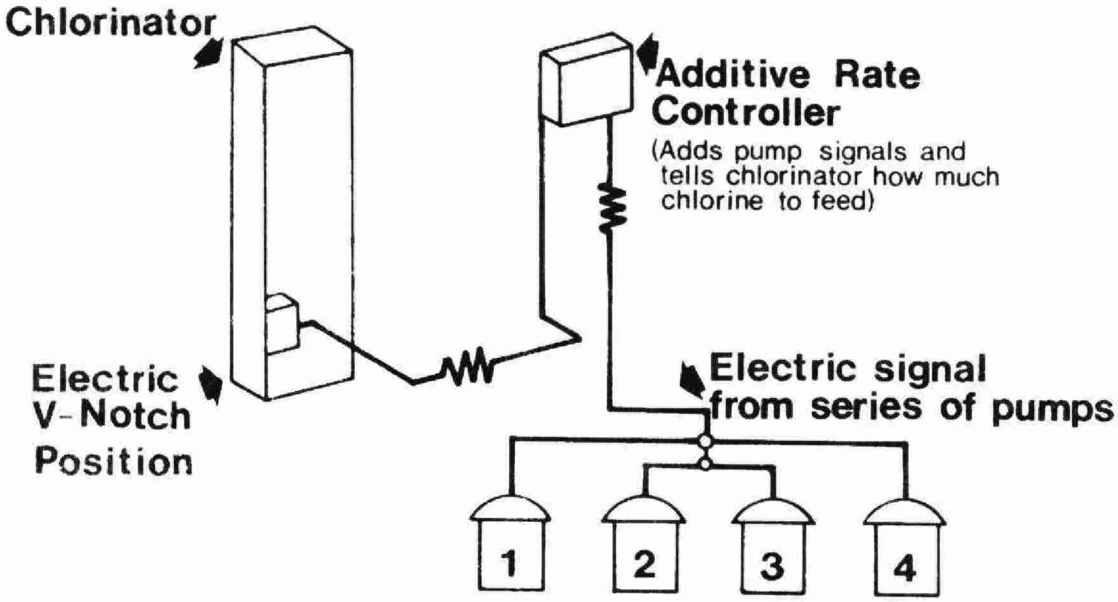


Fig. 3-3 Open Loop Control Chlorination

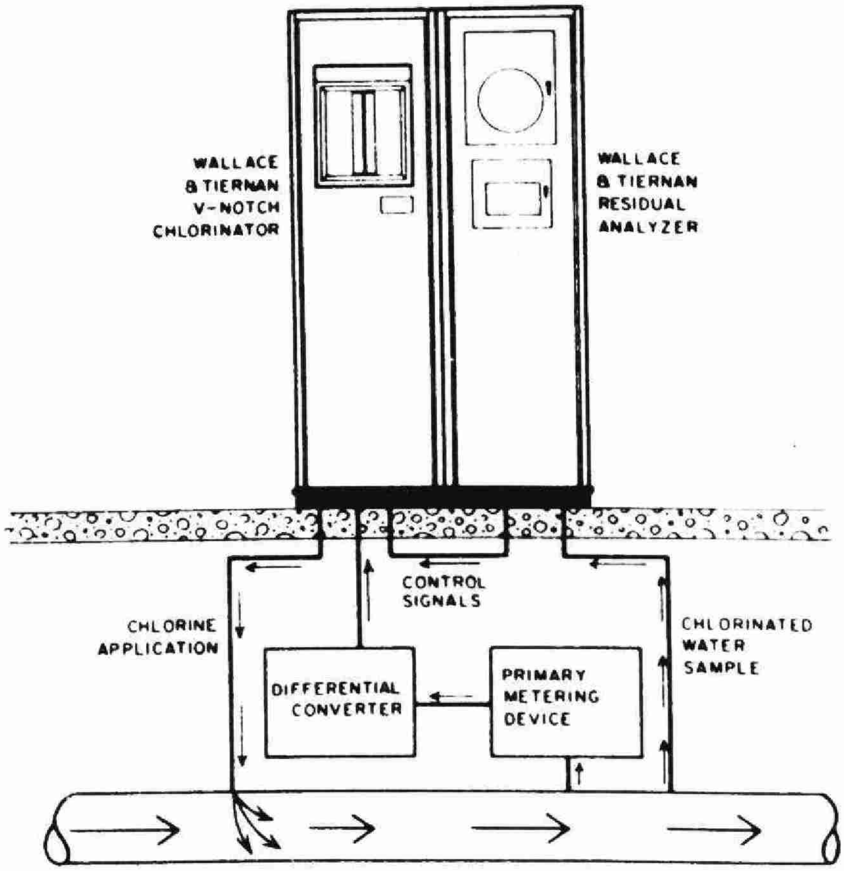


FIG. 3-4 COMPOUND - LOOP CONTROL.

SUBJECT:

CHLORINATION SAFETY

TOPIC: 4

PROPERTIES AND PHYSIOLOGICAL EFFECTS OF CHLORINE

OBJECTIVES:

Trainee will be able to:

1. Define the following chlorine properties:

   - colour,
   - density,
   - expansion rate,
   - solubility,
   - flammability,
   - explosiveness;

2. Recognize the dangers of chlorine.

CHLORINE PROPERTIES

Chlorine is a greenish-yellow gas with a penetrating and characteristic odour. It is 2 1/2 times heavier than air, and one volume of liquid chlorine equals 450 volumes of chlorine gas. It can be compressed into a liquid which has a clear, amber colour. At -29°F it has zero vapour pressure. However, as the temperature rises so does the vapour pressure and at 68°F it is 82 psi gauge pressure. This characteristic has to be considered when

(1) feeding chlorine gas from a cylinder,
(2) dealing with a leaking cylinder.

Chlorine has a high coefficient of expansion. For example, a temperature rise of 50°F (say 20°F to 70°F) will increase the volume from 84% to 89%. Such an expansion could easily rupture a cylinder or line full of liquid chlorine. This is the reason for the regulation that all chlorine containers must not be filled to more than 85% of their volume.

Chlorine by itself is non-flammable and non-explosive, but it will support combustion.

TABLE No. 4-1

CHLORINE
Greenish-Yellow Colour
Heavier than Air
High Rate of Expansion
Moderately Soluble in Water
Non-Flammable and Non-Explosive
Supports Combustion at High Temperature

HARMFUL LEVELS AND EFFECTS OF CHLORINE

Chlorine can be detected by smell, even in very small dosages. The least detectable amount of chlorine in the atmosphere is about 3 1/2 ppm, and when this occurs, the operator should be alerted to potential hazards, such as leaks or faulty equipment. At high concentrations, chlorine will affect the body.

The maximum amount that can be inhaled for one hour without serious effects is about four (4) ppm. At fifteen (15) ppm, chlorine will cause irritation of the throat; at thirty (30) ppm, it will cause serious coughing spells; and at forty (40) to sixty (60) ppm, it is extremely dangerous for one-half hour exposure. A few breaths of air containing 1,000 ppm can kill a man.

Because higher concentrations of chlorine cause irritation of eyes, coughing and laboured breathing, it is unlikely that any person would remain unprotected in a contaminated area *unless he were unconscious or trapped.* The symptoms of advanced stages of exposure are retching and vomiting followed by difficult breathing. In extreme cases, the difficulty with breathing may increase to a point where death can occur from suffocation.

TABLE No. 4-2

WARNING - THE EFFECTS OF CHLORINE GAS

	Chlorine (ppm)	
You can breathe no more than	*4.0*	*safely for 1 hour*
It will take at least ..	*1.0*	*for several hours before you show symptoms of poisoning*
	3.5	*before you can smell it*
	15.1	*to cause throat irritation*
	30.2	*to make you cough*
	40-60	*to be dangerous in 30 - 60 minutes*
	1000	*to kill you in a few breaths*

SUBJECT:

CHLORINATION SAFETY

TOPIC: 5

STORAGE AND HANDLING CHLORINE GAS CYLINDERS (150 LB. AND ONE TON)

OBJECTIVES:

Trainee will be able to describe and/or demonstrate the following:

1. Handling and storage procedures for chlorine cylinders;
2. Connecting cylinders using clamp and adapter;
3. Connecting cylinders using threaded connections;
4. Opening the cylinder valve;
5. Using two or more cylinders;
6. Method of determining contents of cylinder;
7. Closing cylinder valve.

STORAGE AND HANDLING

Chlorine is shipped in three types of containers, 150-lb. cylinders (the most familiar), ton containers and tank cars. The contents of any of these consist of a liquid phase and a gaseous phase. (See Figures 5-1 and 5-7.)

150-LB. CYLINDERS - HANDLING

When unloading and moving full 150-lb. cylinders, do not allow them to be dropped from the truck. Prevent them from falling over or against each other.

When moving cylinders, use a light three-wheeled hand truck with rubber tires. This hand truck should have a clamping arrangement or safety chain at least two thirds of the way up the cylinder.

An experienced operator can safely move a cylinder by rolling it on its bottom edge. When rolling a cylinder in this manner, do not let it get out of control and fall, and do not allow the protective bonnet to turn loose.

When handling chlorine cylinders, the protective bonnet should be in position and is removed only when the cylinder is connected to the chlorinating system. Use the same care in handling full and empty cylinders. Use chlorine cylinders only for transporting and storing chlorine.

To lift a cylinder when an elevator is not available, use a crane or hoist with a special cradle. *Chains, rope slings and magnetic devices should never be used for lifting. Never lift a cylinder by the valve-protective bonnet. WHY?* The hood is not designed to carry the weight of the cylinder.

150-LB. CYLINDERS - STORAGE

Chlorine cylinders are stored upright and arranged to allow removal of any cylinder with a minimum handling of the other cylinders. Storage space should be well ventilated, easy to get at and kept at normal room temperature.

CYLINDERS SHOULD *NOT* BE STORED:

1. Near combustible or flammable materials such as oil, gasoline and waste.
2. On an uneven floor or one covered with debris.
3. Near the inlet of a ventilating or an air-conditioning unit.
4. In sub-surface locations.
5. Near an elevator shaft.
6. Near any source of direct heat such as a furnace, heating element or radiator.

CHLORINE CYLINDERS

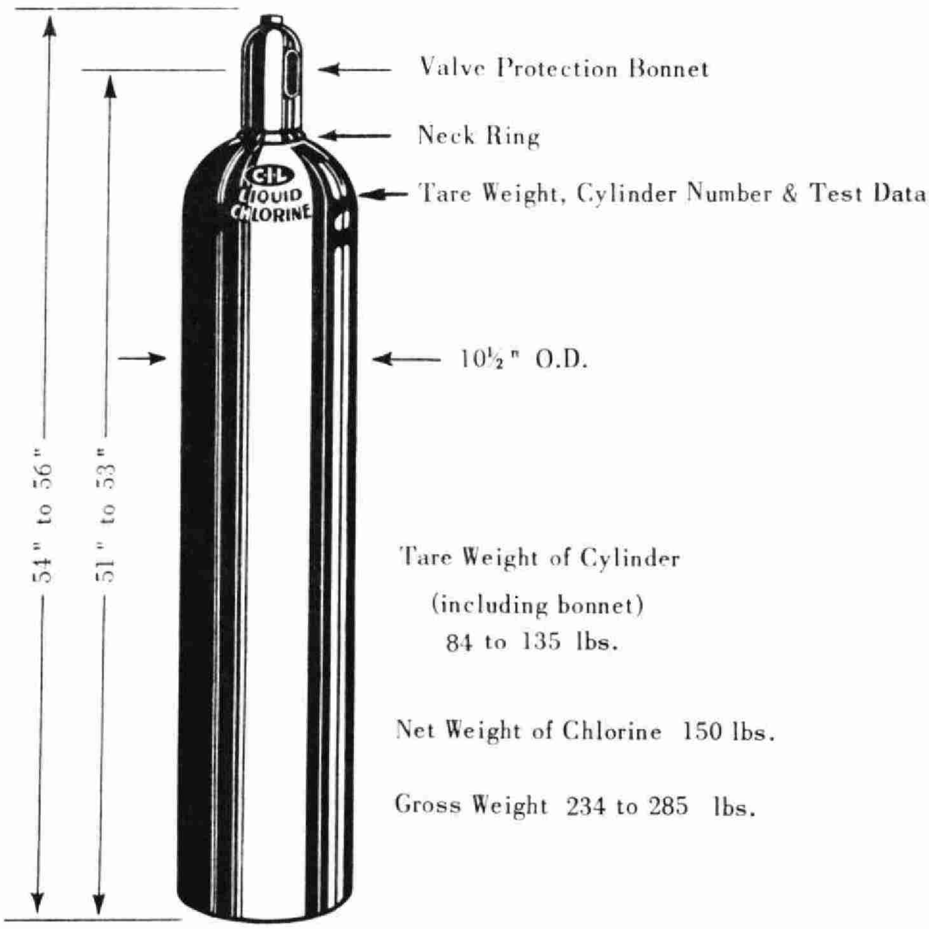


FIGURE 5-1 CHLORINE CYLINDER

Chlorine cylinders are of seamless steel construction and each is equipped with an approved type of valve. Every cylinder is fitted with a bonnet designed to protect the valve from impact due to knocking or dropping.

Letters and numbers are stamped on each cylinder indicating ownership, specification, cylinder number, tare weight and dates of hydrostatic tests. *It is illegal to deface these markings in any way.*

If it is impossible to avoid having cylinders stored or used on a floor below ground level, an adequate exhausting system must be provided for removing any escaped gas. Cylinders should be stored in a dry location because a damp atmosphere will corrode the threads of the protective bonnet, making it difficult to remove.

Empty cylinders should be stored in one area, and full cylinders in another area. Cylinders must be stored in an upright position and prevented from falling over by using a safety chain anchored to the wall with a snap hook and placed around the outside of the cylinders.

<u>150-LB. CYLINDERS - VALVE</u>

The 150-lb. cylinders are equipped with a single Chlorine Institute standard cylinder valve which has a brass body and a Monel stem. There is a packing gland containing two rings of packing and a fusible plug. Valves are tested and reconditioned or renewed by the manufacturer after each trip. The fusible plug is made of poured metal and located on the side of the valve opposite the outlet. The fusible plug will melt at a temperature of 160°F. Its purpose is to release chlorine if pressure becomes excessive due to fire or over-heating. (Refer to Figure 5-4)

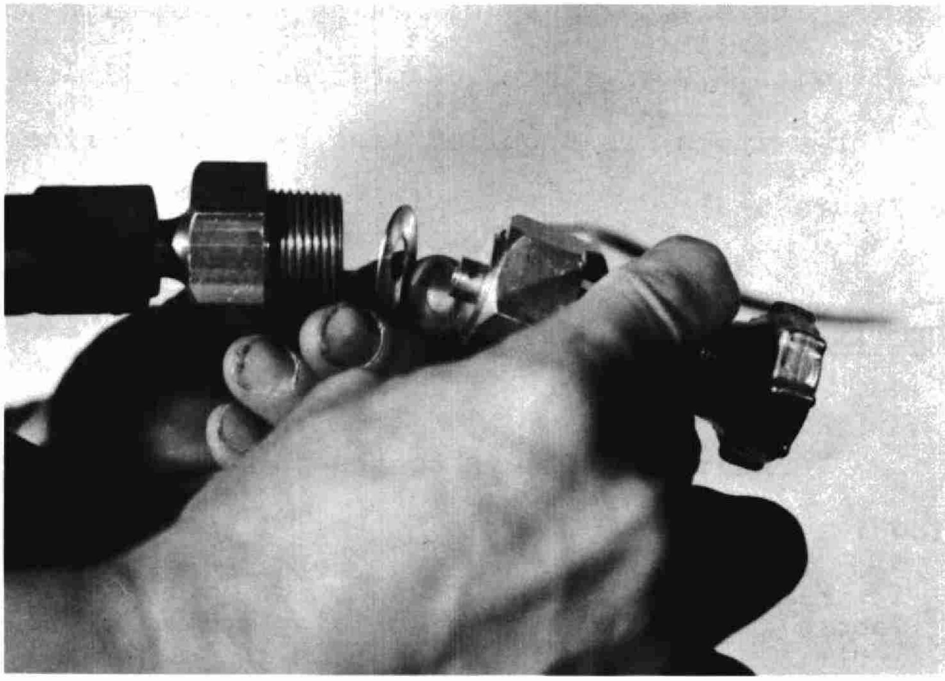


Fig. 5-2 Connecting auxillary valve to Yoke Clamp

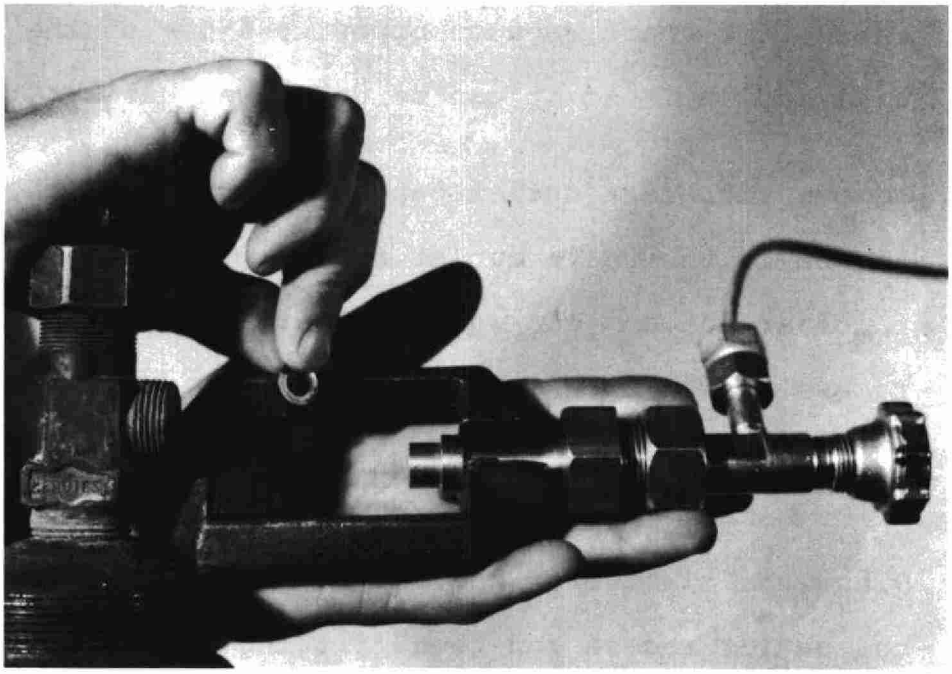


Fig. 5-3 Connecting Yoke Clamp to cylinder using new lead washer

The standard way of making a connection to this valve is with a yoke clamp, adapter and a small lead gasket. These three items are supplied free by the chlorine suppliers (see Figure 5-3).

CONNECTING CYLINDERS USING CLAMP AND ADAPTER

Connect a cylinder to the chlorinating system as follows:

1. Secure the cylinder to a building column or solid, upright support;

2. Remove the protective bonnet. If the cylinder has been exposed to the weather for a long time, the threads at the base of the bonnet may have been corroded, in which case a few smart raps on opposite sides of the bonnet will loosen it so it can be unscrewed easily;

3. Remove the brass outlet cap and any foreign matter which may be in the valve outlet recess. Use a two-inch nail to clear out any old washer or pieces of lead in outlet recess;

4. Place a new lead washer in the outlet recess;

5. Place the clamp over the valve. Insert the adapter in the outlet recess and then, fitting the adapter in the clamp slot, tighten the clamp screw. Make sure the end of the adapter seats firmly against the lead washer. Figure 5-5 shows a cylinder connected to the coil.

NOTE:

150-lb. cylinders are normally used in a vertical position for gas withdrawal.

DO NOT RE-USE LEAD WASHERS.

NEVER LIFT CYLINDER BY THE BONNET.

The protective hood on the 150-lb. cylinders is screwed onto a threaded neck ring. Despite its appearance, the neck ring is actually not part of the cylinder, and is often not securely attached to the cylinder.

ALWAYS KEEP THE HOOD IN PLACE EXCEPT WHEN CYLINDER IS IN USE.

CONNECTING CYLINDER - USING THREADED CONNECTIONS

When making connections with piping having threaded couplings instead of the yoke type, *two wrenches must be used:* the large spanner for the coupling and the small spanner holding the squared area of the pipe itself at the coupling. Use the flat spanner or box-end wrenches supplied by the manufacturer for all chlorine cylinder pipe connections.

NOTE:

Operators must wear protective goggles when working around chlorine equipment.

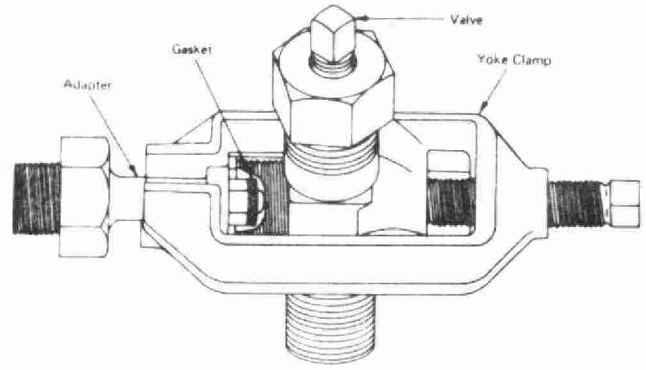


FIGURE 5-4 VALVE CLAMP AND ADAPTER ASSEMBLY

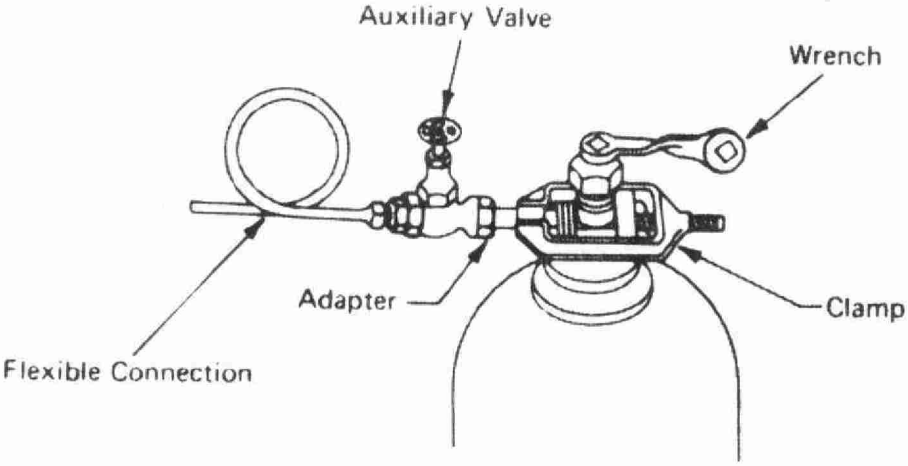


FIGURE 5-5 CYLINDER CONNECTED

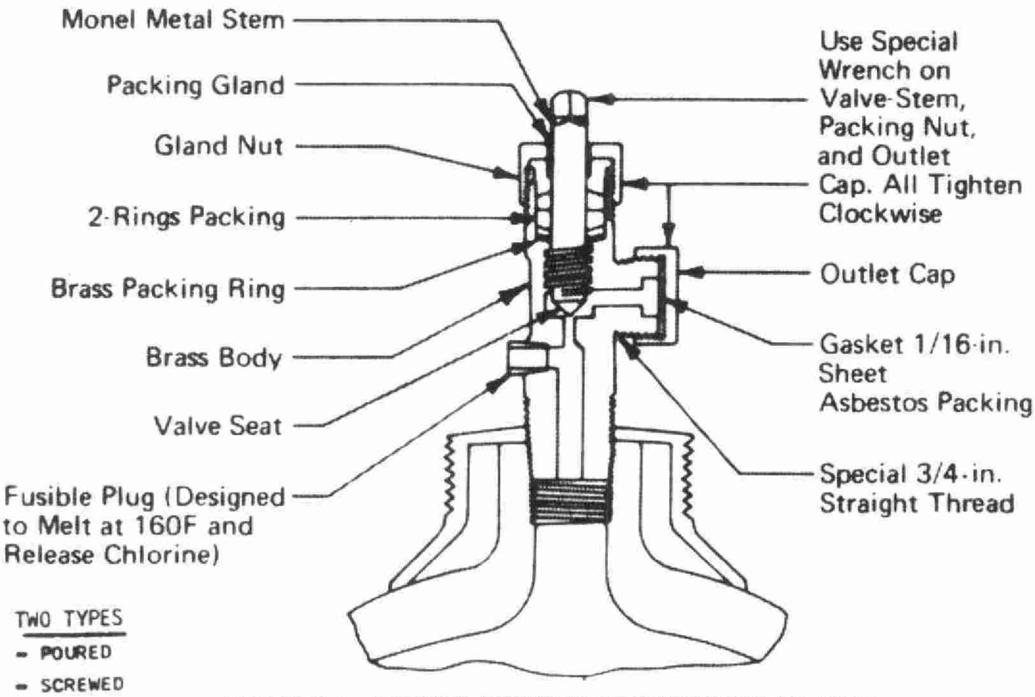


FIGURE 5-6 CHLORINE INSTITUTE STANDARD CYLINDER VALVE

WEIGHING THE CYLINDER

The only reliable method of determining the contents of a cylinder is by weighing. *The pressure in a cylinder depends upon the temperature,* not upon the amount of chlorine in the container. Where convenient, the cylinder should stand on a scale throughout the entire period of discharge. In any event, the only sure method of determining whether or not the cylinder is empty is to weigh it and check its weight against the tare stamped on the cylinder shoulder.

OPENING THE VALVES

Place the wrench provided by the manufacturer on the valve stem, stand behind the cylinder valve outlet and, grasping the valve firmly with the left hand, hit the wrench a sharp blow in a counter-clockwise direction with the palm of the right hand. Do not pull or tug at the wrench as this may bend the stem, causing it to stick and, once opened, the valve may not close properly. *Do not under any circumstances use an ill-fitting manufacturer's wrench or a pipe wrench* since these wrenches will round the corners of the squared end of the valve stem. The manufacturer will gladly supply new wrenches on request. The use of large wrenches for opening stubborn valves should be avoided because, with the extra leverage obtained, there is danger of bending the valve stem or breaking it. To open a stubborn valve, follow the normal opening procedure but use a small block of wood held in the palm of the hand when striking the wrench.

Immediately after the valve has been opened and the flow of chlorine adjusted, tighten the gland nut on top of the valve with the hand. Cylinders are shipped from the manufacturer with the gland nut slack so that the valve packing will retain its elastic properties until required for use. If chlorine is allowed to escape through the gland, the packing becomes hard and unserviceable.

STARTING UP CHLORINATOR USING TWO OR MORE CYLINDERS

Turn on water to the chlorinator, make the necessary adjustments to the machine for operation when the gas is turned on. (See Topic 12 for Start Up)

Crack open the valve of the cylinder farthest from the chlorinator until approximately 40 pounds per square inch (psi) of pressure is recorded on the pressure dial of the chlorinator.

SHUT OFF the cylinder valve and test for leaks. If there are no leaks, wait until the pressure indicated by the gauge returns to zero.

Crack open the valve of the second cylinder and repeat the procedure used on the first cylinder; repeat until all cylinders being used have been tested. If a gas leak develops during the checkout of pipes and cylinders, step out of the chlorine room and wait for the ventilating system to clear the gas from the room. Since the chlorine cylinder was

shut off earlier, the chlorinator needs only to use up the gas in the piping.

At the beginning of the above tests, should the chlorine pressure gauge on the chlorinator fail to record any pressure, shut off cylinder valve immediately. Crack open the valve of another cylinder and close it again in one continuous motion to check out the possibility that the first valve was inoperative. If no pressure is recorded when the second valve has been opened, the feed pipe may be plugged or other operating problems exist. *Do not attempt to repair or make adjustments to any part of the chlorine system until the chlorine gas now trapped in the feed pipes from cylinder to chlorinator has been released.*

Put on a self-contained air pack with full face piece, loosen one of the feed pipe connections and allow the trapped gas to escape *slowly* from the piping. Wait until the room has been cleared of all escaping gas to make the necessary repairs or adjustments.

ONE-TON CYLINDERS - CONNECTING AND TESTING

The procedure for connecting and testing valves and feed pipes for one-ton cylinders to header or chlorinator is the same as described for the 150-lb. cylinders, and should be followed accordingly.

CLOSING THE VALVE

When all the chlorine has been discharged from the cylinder, close the valve after the pressure in the cylinder reaches zero. In closing, *use the wrench provided*, grasping the valve in one hand and tapping the wrench in a clockwise direction with the palm of the other. If the valve does not close tightly on the first trial, it should be opened and closed lightly several times until proper seating is obtained. *Never use a hammer or any other tool to close the cylinder valve tightly.* Replace the outlet cap immediately upon disconnecting the cylinder so that the valve parts will be protected from the moisture in the air. As in the case of full cylinders, screw the protective bonnet in place as soon as the cylinder is disconnected.

The outlet cap of each valve is fitted with a gasket which is designed to fit against the valve outlet face. If a valve leaks slightly after closing, the leak may be stopped by drawing up the valve cap tightly.

If the gasket is not in position, an outlet cap may be taken from another cylinder or a suitable gasket may be cut from an asbestos or synthetic rubber sheet. When the valve cap is used to stop a leak, the gland nut should also be well tightened.

FEED PIPE SUPPORT

The feed pipe or flexible coil from the header to the cylinder should be supported while the empty cylinder is being replaced by a full one. For example, support it on another cylinder, use a hook, or a stick from the floor up (a broom would be handy). This will prevent any kinking or weak spots from developing in the pipe.

If the pipe line is disconnected for any length of time, there is a danger of moisture forming in the line. Plug the open end of the pipe using a cloth, and shut the auxiliary valve.

ONE-TON CYLINDERS - STORAGE AND HANDLING

One-ton cylinders must be moved by an approved lifting bar and hoist, and not by rolling them along the floor.

General storage conditions are the same for both one-ton and 150-lb. cylinders.

Outside storage areas should be sheltered from the direct rays of the sun, or from excess cold. Cylinders should be brought in from the storage area to the chlorine room at least 24 hours before hooking them up to the chlorination system. This allows time for the cylinder temperature to reach room temperature.

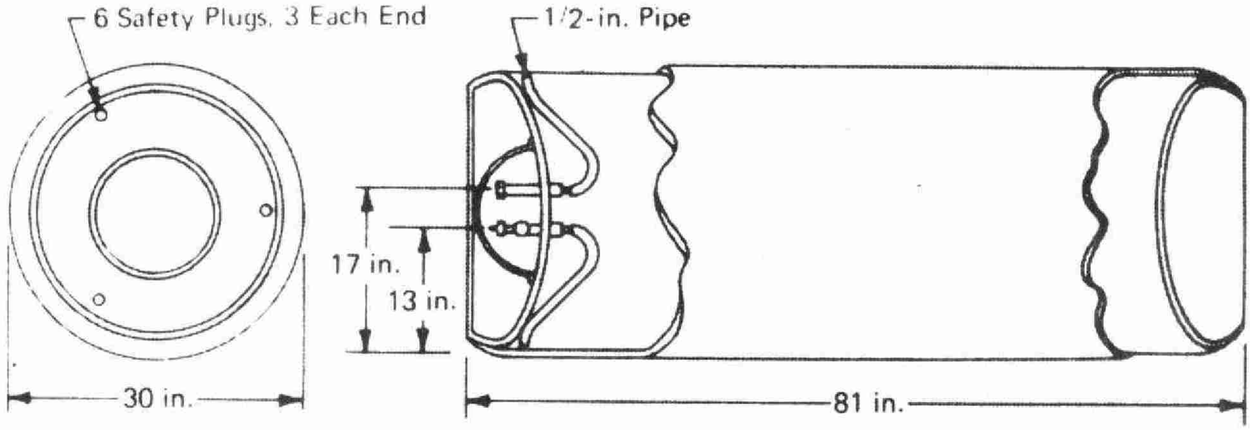


FIGURE 5-7 CROSS SECTION OF TON CONTAINER

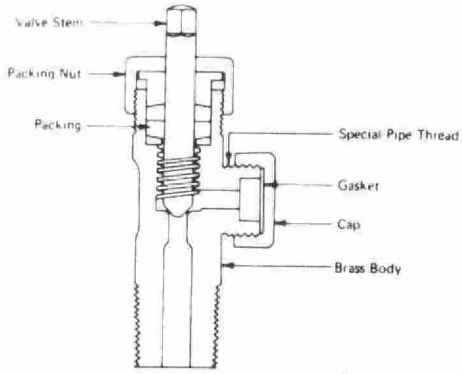


FIGURE 5-8 CROSS SECTION OF THE TON CONTAINER VALVE

A one-ton container has two valves, very similar to the one on the 150-lb. container; in fact, the only difference is that these valves do not have a fusible plug. Instead, the ton cylinder has three separate fusible plugs in each end, which will melt at 160°F and discharge the chlorine from within. The delivery rate of chlorine from a ton container will depend on the temperature of the liquid in the container, but an average flow is about 20 pounds per hour of chlorine gas. Set the one-ton cylinder on the scales with the two discharge valves one above the other. The top valve will discharge chlorine gas. The bottom valve will discharge chlorine liquid. (Refer to Figures 5-7 and 5-8.)

Never operate valves in such a manner as to isolate chlorine gas or liquid in a line. In some installations using one-ton cylinders, there is a short length of tubing running between cylinder(s) and evaporator(s). There is a valve on the cylinder and one on the evaporator line. The tubing between the two is full of liquid chlorine during normal operation. If for some reason the valve on the evaporator line is closed and then the cylinder valve shut, the tubing is left full of liquid chlorine. A small increase in temperature will cause a considerable increase in gas pressure. With the tubing full of chlorine and closed at both ends, there is no room for gas expansion and a potentially dangerous situation exists (see Figure 5-9).

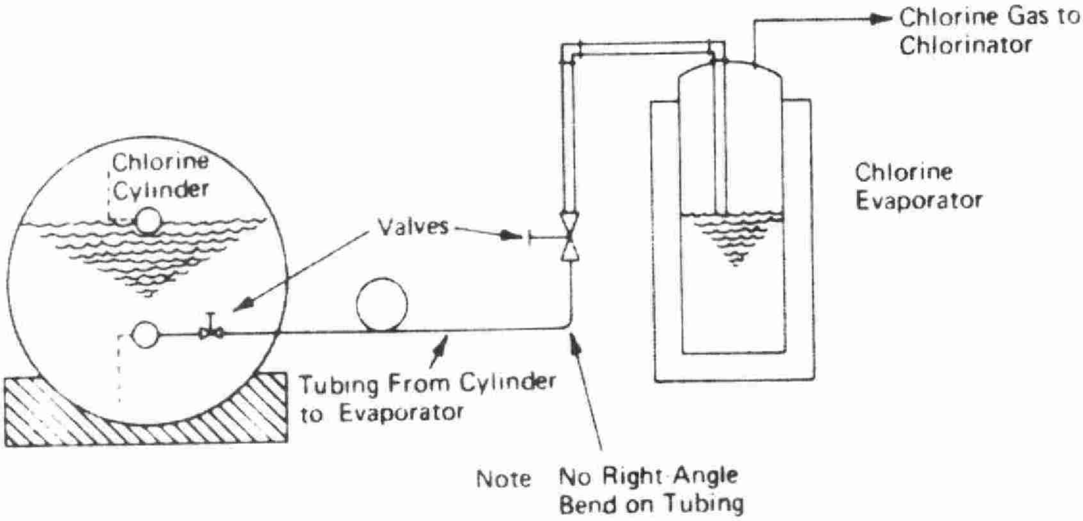


Fig.5-9 Diagram Showing Danger of Sealed System

The safe procedure is to close the cylinder valve first and then allow sufficient time for the chlorine in the tubing to be exhausted by the evaporator before closing the evaporator inlet valve. This is the procedure followed when changing cylinders.

RETURNING EMPTY CYLINDERS TO MANUFACTURER

As a final step before returning an empty chlorine cylinder to the manufacturer, remove the portion of the green warning tag below the perforated line. This identifies the cylinder as an empty container. If a full or partially full chlorine cylinder is being returned, the green warning tag should be left intact.

SUBJECT:

CHLORINATION SAFETY

TOPIC: 6

OPERATING SAFETY INSTRUCTIONS

OBJECTIVES:

Trainee will be able to describe and /or demonstrate Operating Safety Instructions for the following:

1. Chlorine exhaust fan;

2. Self-contained air pack;

3. Chlorine leaks;

4. Changing cylinders;

5. Yoke, adapter and clamp;

6. Removing green slime;

7. Renewing metal chlorine gas piping;

8. Describe the reasons for proper venting of gas feed equipment;

9. Describe the correct methods of venting gas feed equipment where more than one machine is in use as well as different sizes and types.

OPERATING SAFETY INSTRUCTIONS

1. Always turn on the chlorine exhaust fan when entering the chlorine room, whether for a routine check or for servicing or repairing leaking equipment while wearing a mask.

2. Whenever the concentration of the chlorine gas in the air is unknown, a self-contained air pack *must* be worn.

3. Do not start up or operate a chlorinator or turn on a chlorine cylinder unless adequate protective equipment (air pack respirator) is on hand in the chlorine room area.

4. A self-contained air pack must be worn when it is necessary to locate and stop small leaks in the piping or when making any repairs or adjustments to *leaking* equipment.

5. All persons using the gas protective equipment must be trained in its use and maintenance.

6. A self-contained air breathing unit must not be used unless the air cylinder is fully charged. *Air cylinders must be completely recharged after each use.*

7. When a leak occurs in a chlorinator room, close all doors leading into any other part of the building. Only doors to the outside should be opened.

8. Never apply water to a chlorine leak because of the added corrosive action created by the water and chlorine mixture.

9. Wear plastic coated gloves when changing cylinders.

10. Whenever possible, two men should be present when changing chlorine cylinders.

11. Do not lift a cylinder (150 lbs.) up onto the scales. Use a ramp.

12. When connecting the piping from the cylinders to the chlorine machine or whenever it is necessary to break a connection and recouple it, always use a new lead or fibre washer.

13. Soak the yoke, adapter and clamp in kerosene, clean with a wire brush and smear the slide and threaded adjustment screw lightly with a light grease. Inspect the yoke adapter for rounded or worn edges at the contact point of the adapter clamp.

14. The piping from the cylinders to the header located on the wall or to the chlorine machine must have an inverted loop of not less than 10" in diameter in its length. The loop acts as a flexible coupling (see Figure 5-5. Topic 5)

15. A green slime, due to the gas and/or the chemical reaction, may form where a leak was repaired. A *dry* cloth should be used to wipe away the slime. The moisture from a wet cloth would combine with the slime, possibly creating another leak.

NOTE:

If this green slime has dried to a dust, do not blow it with your mouth or brush or wipe it unless the area is completely ventilated.

AVOID BREATHING THIS DUST. Even minute particles are highly dangerous.

16. All metal chlorine gas piping leading from the cylinders to the header or chlorinator should be replaced after each season of use. If chlorination is continued for the full year, the pipes must be replaced at the end of each year of operation. Flexible metal chlorine gas piping should be replaced immediately if bent or twisted during cylinder changeover.

NOTE:

Do not attempt to clean and re-use the pipes. All black iron pipe used as header pipe for gas or liquid chlorine should be replaced after 5 years of service.

17. When using chlorinated powder or chloride of lime for dusting, etc., wear goggles and gloves.

VENTING OF GAS FEEDING EQUIPMENT

In many water treatment plants, more than one type of gas is used. The most common gases used are chlorine and sulphur dioxide or chlorine and ammonia. Since these gases are not compatible, it is necessary to protect the gas feeding equipment.

Venting systems are often hooked into a single common vent line, so that if one machine is drawing from atmosphere and another is discharging to atmosphere at the same time, the discharged gas will be drawn into the other machine. Results would be drastic to internal parts of the equipment and to the interior of the vent line.

Where two chlorinators of different basic characteristics are hooked to a common vent line, it is quite possible for one which has the gas shut off to draw chlorine through the venting system of the other.

Where an old style "water diaphragm" chlorinator (bell jar type) and a new style mechanical diaphragm are connected to a common venting system, the greater volume in the mechanical diaphragm equipment can draw water out of the old style machine through the vent line and into the mechanical diaphragm equipment. Damage would result to lines and internal parts.

NOTE:

The above statement also holds true where this type of equipment is connected to a common gas supply line, and the gas cylinders go empty.

Therefore, common vent lines should be eliminated where:

(a) more than one type of gas is in use;

(b) one type of gas, but machines of different characteristics, size, or manufacturers, are used.

SUBJECT:

CHLORINATION SAFETY

TOPIC: 7

AIR PACKS AND CANISTERS

OBJECTIVES:

Trainee will be able to:

1. Demonstrate in proper sequence the use of the 15-minute air pack;

2. Describe the steps to follow when using the 30-minute air pack;

3. Describe the steps to follow when using the canister.

THE 15-MINUTE "SAC PAC" AIR PACK

Check the pressure gauge periodically to see air cylinders are full.

To Put On:

(1) Open valve one complete turn on back of pack.

(2) Place the air pack on your back and adjust the two straps for comfort.

(3) Open the pouch (pocket) on the bottom of pack and the face mask will fall out.

(4) Put the face mask over face with chin resting in the recessed groove provided in mask.

(5) Adjust head straps from the bottom upwards to the top of the head; *always adjust both head straps on each side of the head at the same time to guarantee centering of mask over face.*

(6) You are now breathing fresh air.

The 15-minute "Sac Pac" Air Pack is only an emergency unit and does not come with a low air pressure alarm.

To Remove Unit:

Reverse the procedure, shut off air valve and purge the system with the by-pass button located on the face mask.

Always refill unit before putting away and extend all straps to their limits.

This unit should be put on in 12 to 18 seconds.

THE 30-MINUTE FRESH AIR "AIR PACK"

Check the pressure gauge on the cylinder periodically to see it reads "full" at all times.

The "Red By-Pass" valve located by the harness air gauge must be closed and the "Yellow Demand" valve *locked* open at all times.

To Put On:

(1) Place air pack on back; buckle the chest and waist belts and adjust pack by the two small straps to the most comfortable position on the back.

(2) Fully open air cylinder valve and lock in open position with the ratchet or locking pin (whichever is provided).

(3) The air gauge located on the left side of chest will now read the same pressure as cylinder gauge.

(4) Put face mask over face with chin sitting in the recessed groove provided in the mask.

(5) Tighten headbands from the bottom upwards to top of head. *Adjust headbands on each side of the head at the same time to guarantee centering of mask over face.*

(6) Test face mask for air tightness by placing hand over hose end and taking a deep breath. If mask draws in around face, air tightness is obtained.

(7) Insert the hose into the hole on the chest air gauge housing provided and tighten the locking nut.

(8) Air pack is now working.

A low air pressure alarm is activated when approximately 500 lbs. of air is left in cylinder. When alarm sounds, leave the contaminated area for a fresh cylinder of air.

To Remove Unit:

Reverse procedure and shut off air cylinder valve and purge the system by opening the red by-pass valve and then reclose it.

DO NOT put the unit away without extending all straps to their limits.

DO NOT put unit away without refilling air cylinder.

CANISTER TYPE GAS MASK

Many operators of water and wastewater treatment plants operated by a municipality or Public Utilities Commission are using canister type gas masks for protection when a chlorine leak occurs. This type of mask provides only limited protection against chlorine gas, even under ideal conditions.

However, if a canister type mask is all that is available for protection, it can be worn with greater safety if maintained properly and its limitations are understood.

> *WARNING:*
>
> *A canister type mask will give no protection when the oxygen in the air is too low to support life, whether it is brand new or used only once. The Ontario Ministry of the Environment has replaced all canister type gas masks with small, self-contained air packs.*

The Canister

The canister contains activated carbon and filters out chlorine gas in the air by absorption. *Each time it is used in contaminated air, its absorption capacity is reduced.* The number of times it can be used before the carbon becomes exhausted is not known. This would depend on how much chlorine was present in the atmosphere during each use.

A brand new canister will protect for ten (10) minutes in a 2% concentration of chlorine gas to air. *After that, it is useless.*

When a canister is in use, pull aside the flap over the intake part on the bottom of the canister to allow the air in the room to enter and pass through to the face piece of the mask. This flap *must be replaced* when the canister is not in use. If it is not replaced, the carbon loses its absorption qualities and will provide little or no protection the next time it is used.

The shelf life of a canister is not really known. When the canister was used by the OWRC (now the Ontario Ministry of the Environment), a total of one year's shelf life was considered the maximum before being discarded.

An expiry date is stamped on the canister; however, if the canister is placed in the canvas holder with the face piece to the front, the date will be facing the back of the holder and cannot be seen.

The Face Piece

The flexible hose should be coiled around when the mask is stored in the box, not bent or kinked.

The head straps should be left in their extended position for instant use.

Do not handle roughly.

Do not wear a face piece with broken head straps.

Keep lens clean; *replace if cracked.*

After each use, the face piece should be cleaned using a cloth and warm water containing a mild disinfectant.

Remember, each time a canister gas mask is used, its effective protection time for any concentration of chlorine gas becomes less.

THE ONLY SURE WAY TO GET THE MAXIMUM PROTECTION FROM A CANISTER IS TO USE IT ONLY ONCE AND THEN THROW IT AWAY.

PROCEDURE USING 15-MINUTE PAC UNIT

Fig. 7-1 Sac Pac Unit can be stored on a nail or hook

Fig. 7-2 Turn on cylinder air valve before putting unit on.

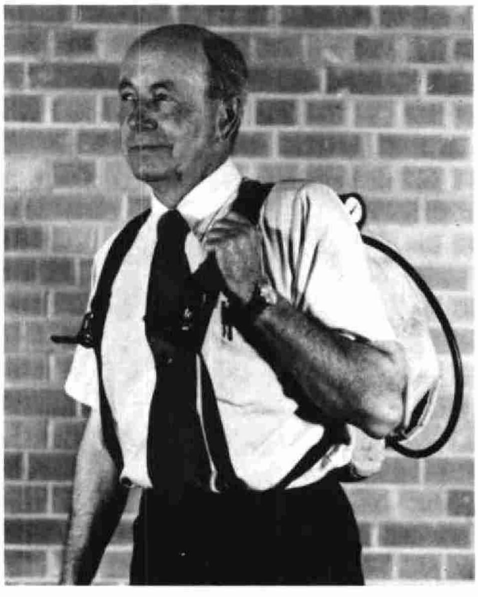


Fig. 7-3 Swing unit up and over left shoulder, then slide arm through right strap.

Fig. 7-4 Pull adjustment straps to tighten shoulder straps and secure unit to body. Position unit on back so it is comfortable.

Fig. 7-5 Pull flap of facepiece cover with right hand.

Fig. 7-6 Face piece falls out to full length of hose catch before it touches floor.

Fig. 7-7 Extend head straps full length, fold back head harness outward and place face piece on chin first.

Fig. 7-8 Tighten head straps, starting with bottom straps on each side. Test air tightness of face piece by closing off air intake and breathing in.

PROCEDURE USING 30-MINUTE AIR PAC

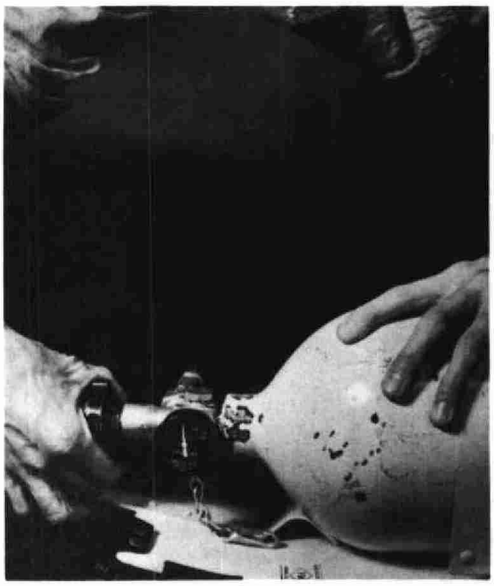


Fig. 7-9 Air valve can be turned on while A Pac is in carrying case.

Fig. 7-10 Swing unit onto back, shoulder straps adjust so that cylinder rests in comfortable position on back.

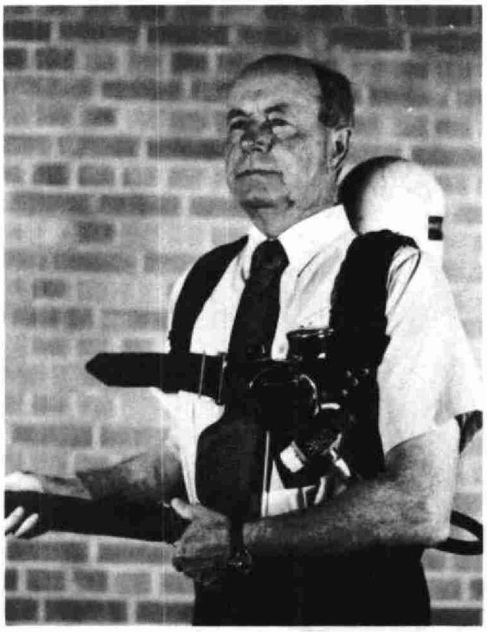


Fig. 7-11 Tighten chest and waist straps.(Newer Air Pac models do not have chest strap).

Fig. 7-12 See Fig. 7-7 for putting face piece on. Test for air tightness by blocking hose and drawing in breath.

Fig. 7-13 Attach hose to regulator

Fig. 7-14 30 Minute Air Pac now ready for use.

PROCEDURE USING CANISTER TYPE RESPIRATOR

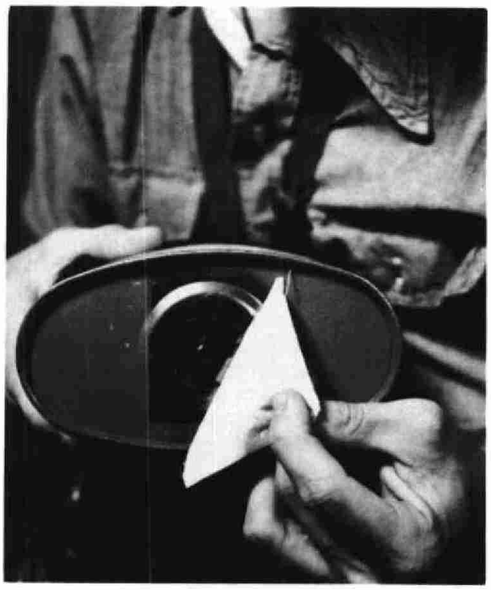


Fig. 7-15 The first thing to do after removing unit from case is to pull adhesive flap from the intake port.

Fig. 7-16 After placing harness around neck, and adjusting the neck strap so that canister is at waist level put mask on similar to Fig. 7-7. See picture above for testing face piece tightness.

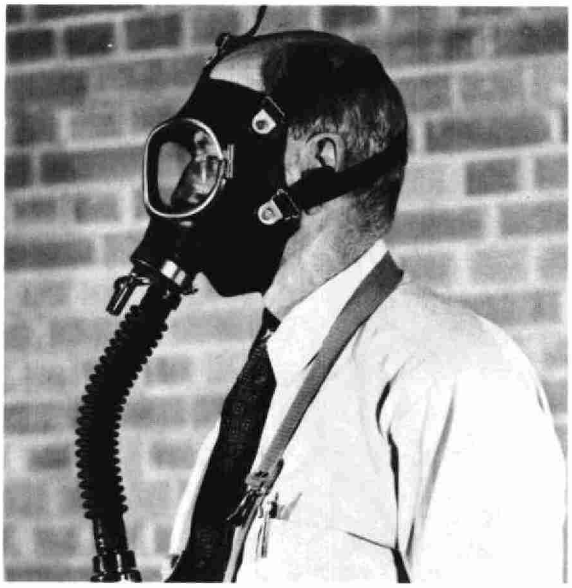


Fig. 7-17 Fasten face piece hose to canister and unit is ready for use.

SUBJECT:

CHLORINATION SAFETY

TOPIC: 8

LEAK DETECTION AND REMEDIES

OBJECTIVES:

Trainee will be able to describe and/or demonstrate the following:

1. Safety procedures - leak detection;
2. General rules to follow when leaks are discovered;
3. Types of leaks encountered - and their remedies.

LEAK DETECTION AND REMEDIES

To avoid accidents when working with chlorine, follow the procedures carefully. In the event of a mistake or accident, however, suitable gas masks should be available so that emergency measures can be taken. The chlorinating room itself should be adequately ventilated with a separate ventilating system capable of removing the air from the room once every four minutes. This ventilation should be located at a low level in the room because the chlorine gas is heavier than air. Any room with chlorine containers should have two exits and the doors should open outwards for easy escape. Gas masks should be located just outside the chlorinating room as should the switches for the ventilating system.

SAFETY PROCEDURES - LEAK DETECTION

If you smell a leak:

(1) Procure and adjust gas mask for immediate use.

NOTE:

Gas masks should be located OUTSIDE of the chlorine room beside the door leading to the chlorine room.

(2) Turn on exhaust fan of chlorine room. Check fan discharge point and be sure personnel or equipment are not in the way.

(3) Shut off cylinders. If leak is large, or if the equipment has been leaking for some time, the room is full of gas.

__NOTE:__

No tests can be made on equipment for leaks until room is cleared.

DO NOT ATTEMPT A REPAIR ALONE.

(4) Notify supervisor immediately.

(5) To test for leak AFTER room is cleared:

(a) use bottle of concentrated ammonia; swab near joints, piping or valves suspected. *White fumes of ammonium chloride indicate the location of a chlorine leak.*

(b) crack open cylinder FARTHEST from chlorinator until gauge shows approximately 40 lbs.

(c) shut off cylinder and test system to find leak(s). *It may be necessary to repeat above action several times to find all leakage.*

(6) When location of leak is found:

(a) mark it off clearly.

(b) shut off gas supply and *keep supply shut off until leak is repaired.*

(c) use proper tools for repair; do NOT handle equipment with unnecessary roughness.

(7) If leak is not repaired before shift change:

(a) advise next operator of what has happened.

(b) advise him of procedures to follow.

NOTE:

If operator of first shift is alone, he should enlist the aid of the operator relieving him to check out equipment, repair leak and leave equipment in operational order before leaving.

TYPES OF LEAKS ENCOUNTERED - AND THEIR REMEDIES

1. Liquid Leak

One basic and very important rule when dealing with chlorine leaks is always to keep the leak in the vapour phase. This is usually quite simple in the case of 150-lb. cylinders, since they are stored and usually used in an upright position. With one-ton cylinders, however, liquid chlorine could easily

leak through a valve or a fusible plug. Liquid chlorine will vaporize to approximately 450 times its volume as a gas.

The leak will be greatly reduced by rolling the tonner (if possible) into a position where gas is escaping instead of the liquid chlorine. As the gas escapes, the liquid will refrigerate itself, lowering the vapour pressure.

2. Leak at Valve Packing

This can be caused by dried-out packings. In this case, chlorine will be coming out around the valve system and cannot be stopped by tightening down the packing gland nut. This should only occur when valve is opened.

If leak is very slight, hook up cylinder and start drawing chlorine at maximum rate. This should quickly reduce the pressure and probably stop the leak. If leak is of major proportions and does not respond to this treatment:

- shut off valve
- set cylinder outdoors *in the shade*
- call supplier who will pick up cylinder or replace the packing.

3. Leak at Fusible Plug

This is usually due to corrosion from moisture, either internally or from the outside.

(a) Cylinders

One manufacturer has a special clamp with a rubber pad and steel backing which easily controls this type of leak. The adapter clamp can also be used to stop this type of leak. Take a flat file and file the area around the fusible plug flat. Apply a small patch of synthetic rubber gasket material with a follow-up piece of metal and clamp this firmly in place.

NOTE:

This emergency device now leaves the cylinder without protection from high temperatures. Use up the chlorine in the cylinder as rapidly as possible.

(b) One-Ton Container (Tonner)

Leak can be at fusible metal or in thread around plug. If leak is through fusible metal, there is a special clamp of rubber and steel which readily controls the leak. If leak is around threading of fusible plug, the Chlorine Institute emergency kit may have to be used. *Remember:* when a fusible plug clamp is applied to a 150-lb. cylinder, the safety device no longer exists and it must be emptied as quickly as possible. Since there are six fusible plugs on a tonner, sealing off one of them still leaves five operating safety devices which should be enough under most circumstances.

4. <u>Valve Stiffness</u>

Valves are carefully checked before leaving the manufacturer's plant, but occasionally a valve may be stiff to turn or difficult to shut off tight. This may be caused by a small piece of scale or other foreign matter at the valve seat. Sometimes the valve can be freed by opening and shutting a few times (with the outlet cap in place and by tapping the body of the valve). Actually, once the cylinder is hooked up, inability to completely shut off the valve is not important and contents can be withdrawn until empty. When cylinder has been discharged (and only gas remains in it), the outlet cap with a good fibre gasket will effectively stop chlorine from escaping.

5. <u>Valve Defect - "Turning Spindle"</u>

The most troublesome type of valve defect (although fortunately not the most common) is known as a "turning spindle". Actually this is a situation where the brass threading on the valve body has been stripped by the harder Monel metal of the valve stem.

If this condition develops *after* the cylinder is hooked up to the chlorinator, the simplest and safest way to deal with it is to continue withdrawing chlorine until the cylinder is empty. However, if the cylinder has not yet been hooked up, then an emergency device is required to deal with the situation.

One manufacturer, CIL, has developed a small unit which fits on top of the valve, and by exerting pressure against the packing gland nut, pushes the valve stem into position. While this device will work in most instances, there are some situations where the use of the larger Chlorine Institute equipment with the capping device is required.

6. Removing Valve Outlet Cap (on Cylinder or Tonner)

ONE VERY IMPORTANT WORD OF CAUTION - when taking off the valve outlet cap (on cylinders or tonners) *DO IT VERY SLOWLY.* Actually, if there is a leak of chlorine past the valve, this will be very noticeable after the cap has been slackened only one turn. Use the ammonia bottle at this stage, and wear a mask. Very small concentrations of chlorine can be detected by smell, and for this reason it is sometimes desirable to leave the mask off - just in case there are leaks. However, the mask should be *immediately available* if required.

7. AS A LAST RESORT - CONTACT MANUFACTURER!

If these remedies do not solve the leaking problem, CONTACT THE MANUFACTURER. In some cases, a telephone call may provide the operator with the necessary information to correct the leak.

If this is not enough, the manufacturer's technical personnel should come, bringing the necessary emergency equipment to stop the leak.

SUBJECT:

CHLORINATION SAFETY

TOPIC: 9

FIRST AID

OBJECTIVES:

Trainee will be able to demonstrate and/or describe the following first aid procedures regarding chlorine:

1. Remove patient from gas area;
2. Place patient on back, elevate head and back;
3. Call physician immediately;
4. Remove clothing contaminated with liquid chlorine;
5. Administer mixture of carbon dioxide and oxygen;
6. Give milk in mild cases as relief from throat irritation;
7. Administer artificial respiration;
8. Cleanse the eyes;
9. Cleanse the skin splashed with liquid chlorine.

NOTE: All first aid procedures should be endorsed by a qualified physician.

FIRST AID

(1) Remove patient from gas area. Patient should be kept in a warm room (about 70°F). Supply blankets under and over patient. Keep patient warm and quiet. Rest is essential.

(2) Place patient on back. Place a folded coat, blanket, etc., under victim's shoulders so his head falls well back. This maintains a clear air passage to lungs of victim.

(3) Call a physician *immediately*.

(4) Promptly remove clothing contaminated with liquid chlorine, or chlorinated water. Keep patient warm with blankets.

(5) A mixture of carbon dioxide and oxygen, with no more than 7% carbon dioxide, may be given. This mixture, already prepared and sold with the necessary apparatus, can be administered for periods of two minutes followed by two-minute rest periods for no longer than thirty minutes. Follow instructions of the gas apparatus supplier carefully. If carbon dioxide and oxygen mixture is not readily available, then oxygen alone may be used, or fresh air "Air Pack".

(6) Milk may be given in mild cases as a relief from throat irritation.

(7) If breathing seems to have stopped, immediately start "Mouth to Mouth" or "Revised Sylvester" methods of artificial respiration. *Do not exceed 17 to 18 movements per minute.* If possible, assist respiration with an inhalator or respirator.

(8) When eyes are irritated with chlorine, wash repeatedly with water and then with 1% boracic acid solution. Castor or olive oil drops may be used. In severe cases of eye contamination due to chlorine, use bubbler fountain, hose, or eye cup. Irrigate for 15 minutes, rest for 10 minutes and irrigate for 5 minutes. A routine of 5 minutes irrigation and 10 minutes rest should then be followed for one hour. Prompt action is absolutely essential to protect eyesight.

(9) Areas of the skin which have been splashed with liquid chlorine or chlorinated water should be repeatedly washed with water. After thorough washing, any burned area should be covered with a sterile dressing and bandaged snugly unless blisters are apparent; then bandage loosely.

If facilities are available, it is generally recommended that patients be removed to hospital as soon as possible, unless recovery from chlorine exposure is prompt and the exposure mild.

REVISED SYLVESTER METHOD OF ARTIFICIAL RESPIRATION

Lose no time in starting - delay can be fatal.

(1) Clear mouth of any obstructions.

(2) Lay casualty victim on his back.

(3) Elevate shoulders of victim with a folded coat, blanket, etc., so his head falls well back. This maintains a clear air passage to his lungs.

(4) Place victim's head between your knees and grasp his arms at the wrist.

(5) Cross arms over the lower half of the breastbone and rocking forward, press firmly downwards (about 20 lbs. pressure), forcing air out of lungs of victim.

(6) Release the pressure by rocking back and pull his arms upwards, outwards and backwards. This extends the chest walls and draws air into the victim's lungs.

(7) Repeat cycle 12 to 15 times per minute until doctor arrives and says to stop, or until normal breathing is restored, or rigormortis has set in.

ORAL RESUSCITATION

Lose no time in starting - delay can be fatal.

(1) Clear mouth of any obstructions.

(2) Lay casualty victim on his back.

(3) Place a folded coat, blanket, etc., under victim's shoulders so his head falls well back. This maintains a clear air passage to his lungs.

(4) Kneel beside victim's head.

(5) Pinch victim's nose and open your mouth wide and blow into victim's mouth strongly enough to cause the victim's chest to rise.

(6) Remove your mouth. Victim's chest should fall.

(7) Repeat cycle 12 to 15 times per minute until doctor arrives and says to stop, or normal breathing is restored, or rigormortis has set in.

Artificial respiration must be continued until natural breathing is restored, a doctor says to stop, or rigormortis sets in.

SUBJECT:

CHLORINATION SAFETY

TOPIC: 10

EMERGENCY PLAN

OBJECTIVES:

Trainee will be able to:

1. Describe and/or demonstrate the emergency procedures to follow if there is a leak from a cylinder which cannot be stopped or repaired;

2. Know which of the following persons to contact:

   (a) his immediate supervisor

   (b) the Fire Department

   (c) the Police Department

   (d) the chlorine supplier

   (e) the Medical Officer of Health

   (f) the Ministry of the Environment Regional Engineer or Supervisor of Water Works.

NOTE: The trainee is not expected to perform the second objective while on the course, but rather be aware of the person or persons to be contacted when an emergency arises while he is on the job.

EMERGENCY PLAN

Chlorine is a potential killer when the chlorine handling equipment, although well designed, becomes defective or when people become careless. Even when all regulations are observed, safety practices followed and well-trained crews are employed, there is still a chance that an accident will occur.

Suppose there is a leak from a cylinder which cannot be stopped or repaired, such as a leaking fusible plug, damaged cylinder valve, or a hole in the cylinder body. The following steps should be taken:

(1) Protect yourself AT ALL TIMES during the emergency, and be sure you will not be overcome by the leaking gas. Use an air pack when in the area of the leaking cylinder.

(2) Contact your supervisor immediately and advise him of the problem.

(3) If you cannot contact your supervisor, telephone the Police Department to tell them of the problem. Advise the police of the wind direction (if any) so they in turn can alert the residents who may be in the path of the gas and have the area evacuated.

The police or operator should also contact the Fire Department who in turn should have someone with an auxiliary air pack go to the plant or leaking area. This person (or persons) could then stand by while you try to stop the leak.

(4) One basic and very important point to remember when dealing with chlorine leaks is always to keep the leak in the vapour phase. Cylinders and tonners should be placed in a position where gas and not liquid is coming off. Chlorine may be absorbed in a solution of caustic soda, soda ash or hydrated lime. Table 10-1 indicates the solutions required to absorb either a cylinder or ton container of liquid chlorine.

TABLE 10-1

ALKALINE SOLUTIONS FOR CHLORINE ABSORPTION						
Chlorine Container Size	Caustic Soda		Soda		Hydrated Lime	
	Pounds 100%	Water Imp. Gal.	Pounds	Water Imp. Gal	Pounds	Water Imp. Gal.
150 pound	188	60	450	150	188	188
One Ton	2500	800	6000	2000	2500	2500

(5) Contact the supplier, or manufacturer, of chlorine. The suppliers operate an emergency telephone call service designed to provide assistance at any hour of the day or night.

(6) Inter-connecting doors within the plant should be *CLOSED, AND THE CHLORINE ROOM SEALED OFF.* The chlorine room exhaust fan should *NOT* be turned on as this would release an excessively strong concentration of chlorine outside the plant. The chlorine will slowly escape by itself if left alone, which is a better alternative, particularly if the leak occurs at night. If the leak occurs in the daytime, the sun will dissipate it quite effectively, even on a cloudy day. If the weather is hot and humid, or rainy, or foggy, the chlorine will not dissipate as quickly, and there is very little which can be done except to evacuate all the people in the area. If there is a wind, the residents who may be in the path of the gas must be evacuated.

(7) If the leak occurs in a water treatment plant, it may be necessary to shut down and use only the water in the reservoir(s). If this is inadequate and the plant cannot be shut down, then the Medical Officer of Health (MOH) should be advised so that he in turn can warn the residents to boil the water from the tap before use.

(8) Immediately advise the Ministry of the Environment Regional Engineer for the area. If he cannot be reached, a call to the Supervisor of Water Works, Sanitary Engineering Branch, at Head Office, should be placed. THE TELEPHONE NUMBER IS (416) 965-1491.

(9) All events which occurred during the emergency should be recorded in the Operator's Daily Log Book.

(10) If the leak occurs in a wastewater treatment plant, the plant can still continue to operate. Again, all events which occurred during the emergency should be recorded in the Operator's Daily Log Book.

NOTE:

WATER WORKS OPERATORS

IN CASE OF CHLORINATION SYSTEM BREAKDOWN

DO NOT PUMP UNCHLORINATED WATER TO THE DISTRIBUTION SYSTEM. NOTIFY THE SUPER-INTENDENT IMMEDIATELY. IF CHLORINATION SYSTEM CANNOT BE RESTORED TO WORKING ORDER IN TWO HOURS, NOTIFY THE MEDICAL OFFICER OF HEALTH AND THE REGIONAL ENGINEER, MINISTRY OF THE ENVIRONMENT, OR SUPERVISOR, WATER WORKS, SANITARY ENGINEERING BRANCH, TELEPHONE NUMBER (416) 965-1491.

SUBJECT:

CHLORINATION EQUIPMENT

TOPIC: 11

COMPONENTS

OBJECTIVES:

Trainee will be able to identify (orally or in writing) the principal parts of the chlorination system.

The principal parts are:

(1) chlorine gas cylinder

(2) chlorine weighing scales

(3) flexible coils

(4) chlorine manifold or header

(5) chlorinator (including chlorinator valves)

(6) water pressure regulator

(7) booster pump

(8) strainer preceding injector

(9) valves (excluding chlorinator valves): cylinder, auxiliary header, check, relief, pressure reducing

(10) evaporator

(11) exhaust fan

(12) safety devices (alarm system, rupture discs)

(13) recording charts and pens

(14) compressors

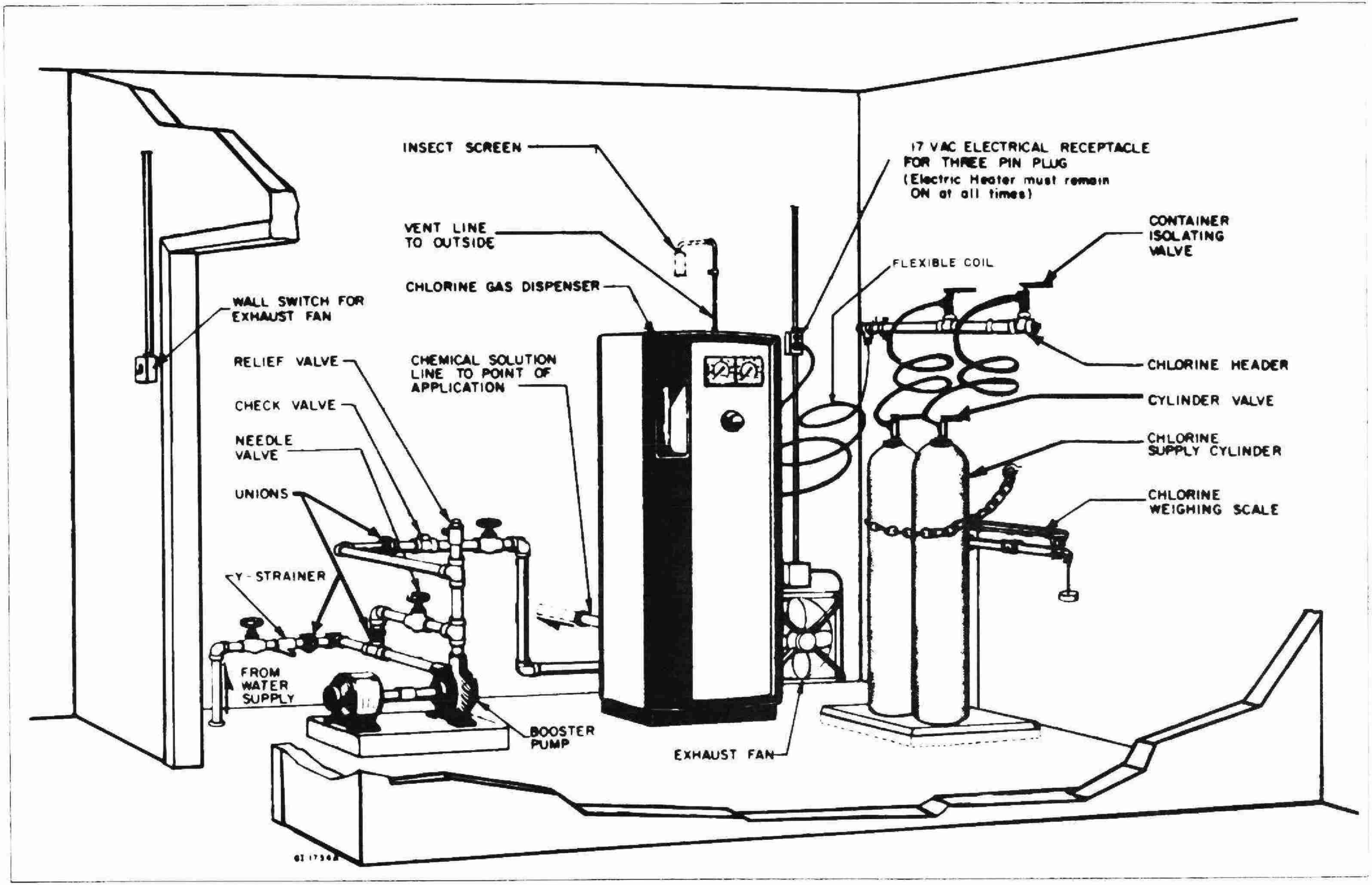


FIG. II-1. Typical Gas-Dispenser Installation.

COMPONENTS

1. Chlorine Gas Cylinder(s) (see Fig. 11-1)

Chlorine gas is shipped from the supplier to the water or wastewater treatment plant in 150-lb. cylinders, one-ton cylinders and in tank cars. The type of container used will depend on the amount ordered and shipped. (See Chlorination Safety, Topic 5, for further details on handling and storage.)

2. Chlorine Weighing Scales (see Fig. 11-1)

The only reliable method of determining the contents of a cylinder is by weighing.

The types of scales used in the water and wastewater treatment industry are (a) beam scales, (b) dial scales, and (c) special types of scales.

(a) *Beam scales* are the most common type used in smaller water and sewage treatment plants. Beam scales have a knife-edge type of platform. The weight to be measured is placed on the platform and determined by moving a counterweight along the beam until the beam is balanced.

(b) *Dial scales* usually have the same type of knife-edge platform as beam scales, but the weight to be measured is indicated directly on the dial. Dial scales are used extensively to measure the amount of chlorine in ton cylinders.

(c) Depending on the circumstances, special types of scales are also used: electronic, loss of weight recorders, transmitters for remote reading and/or recording, 150-lb. container scales and other types.

3. Flexible Coils (or Pigtails) (see Fig. 11-1)

Flexible coils are used to connect the cylinder valve (or the cylinder) to the manifold or header valve. They allow movement of the cylinder on the weigh scales, and allow easy connecting and disconnecting of the cylinder.

NOTE:

1. *Do NOT make any sharp bends or kinks in the flexible coils.*

   WHY? (1) to prevent blockage in line.

   (2) to prevent possible break in line.

2. *When connecting or disconnecting the coil and the cylinder, always use the two wrenches designed for that purpose.*

   WHY? (1) to hold the flexible coil and prevent twisting.

   (2) to prevent breaking of flexible coil off cylinder or header.

4. <u>Chlorine Manifold or Header</u> (see Fig. 11-1)

The chlorine manifold or header is the section of SOLID piping between the chlorinator and cylinder(s) through which the chlorine gas passes from the cylinder(s) to the chlorinator. The flexible coils from individual cylinders are connected to it. Valves should be installed at each flexible connection to permit isolation of a cylinder from the system.

5. <u>Chlorinator (including chlorinator valves)</u> (see Fig. 11-1)

The chlorinator consists of the following:

(a) <u>Chlorine Pressure Regulating Valve (CPRV)</u>

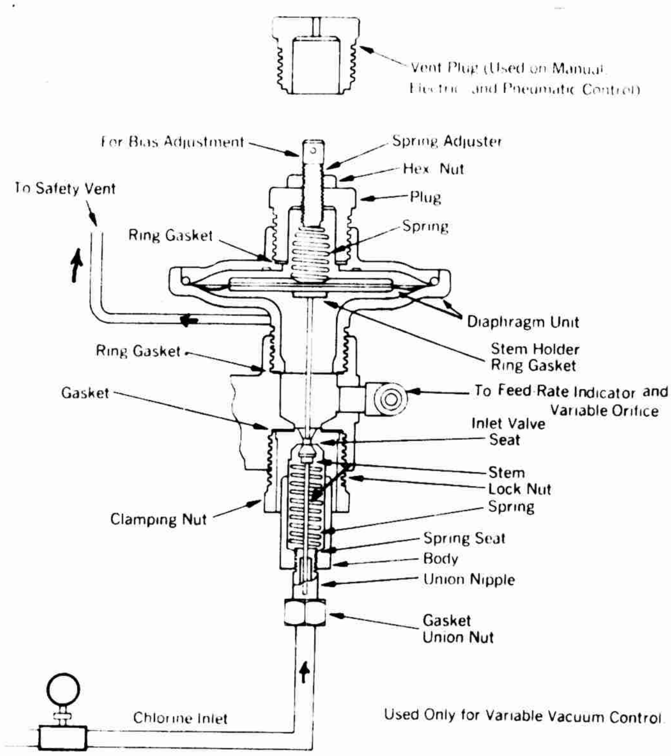


Fig .11-2. Chlorine Pressure-Regulating Valve

On leaving the header, the gaseous chlorine enters the chlorinator through the CPRV. The CPRV is a diaphragm valve which works against a spring force. It maintains the proper operating vacuum ahead of the variable orifice. The vacuum in the chlorinator must be greater than the spring force in the CPRV to draw chlorine gas into the chlorinator. The vacuum pulls the diaphragm and stem down; chlorine gas flows through the feed rate indicator at the indicated pounds per day setting. The spring force in the CPRV controls absolute pressure (or vacuum) in the regulating valve (see Fig. 11-2 and Fig. 11-10).

(b) <u>Feed Rate Indicator (or Rotameter)</u>

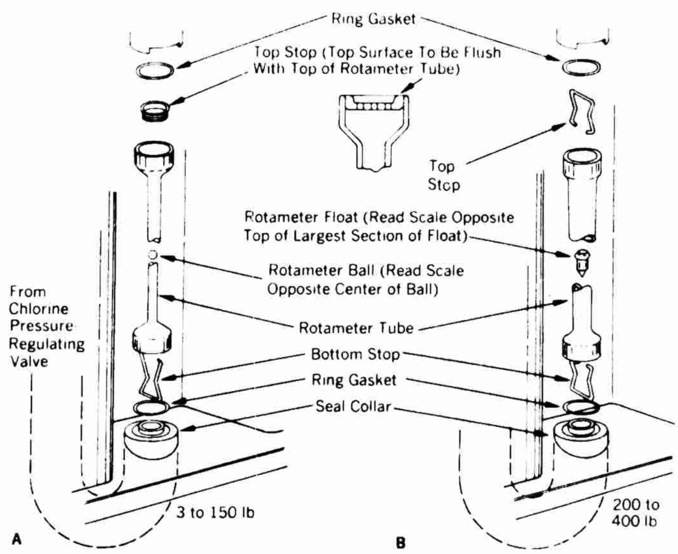


Fig. 11-3. Feed-Rate Indicator

The feed rate indicator, or rotameter (see Fig. 11-3 and Fig. 11-11), is a tapered glass tube with a round ball inside. The ball will position itself in the rotameter according to the chlorine gas flow. The size of the glass tube depends on the gas flow required. When operating normally, the ball is free to rotate inside the tube. If it is not rotating, the ball is stuck against the inner walls of the tube because the inner walls are dirty. Use trichloroethylene to clean the rotameter.

NOTE:

Gas flow readings are taken across the centre of the ball, not across the top or the bottom. Other types of floats are also used, and will depend on the size of chlorinator and the gas flow through the unit. The point of reading on a float will depend on the manufacturer. Read his instructions. The feed rate indicator tube and float are pre-determined for a specific maximum capacity and cannot be interchanged. For example, a float from a 10 lb./day maximum capacity rotameter cannot be used in a 20 lb./day maximum capacity tube.

(c) Pressure-Vacuum Relief Valve

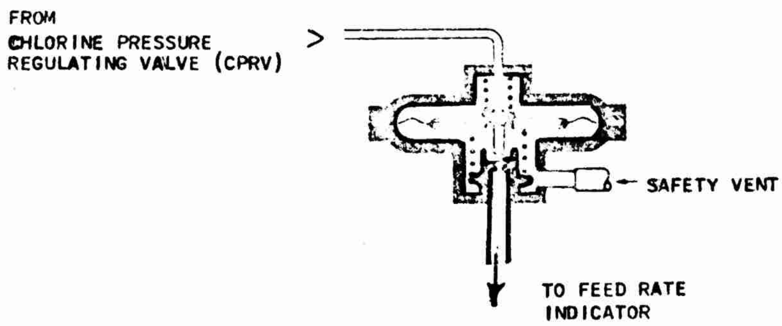


FIG 11 - 4 PRESSURE VACUUM RELIEF VALVE

The pressure-vacuum relief valve is a diaphragm-operated, two-way, spring-loaded valve and is used to provide vacuum relief in the chlorinator system or draw air into the chlorinator. It prevents a build-up of vacuum which could damage the unit, and vents chlorine to the atmosphere if there are problems in the chlorine pressure regulating valve (see Fig. 11-4 and Fig. 11- 2).

(d) Variable Orifice

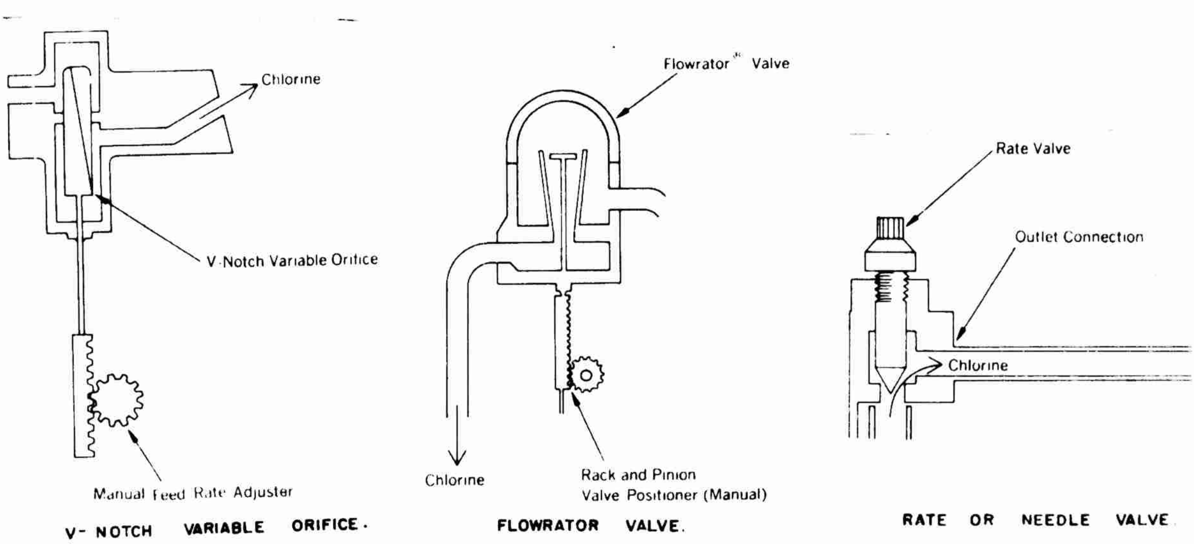


FIGURE 11-5 TYPES OF VARIABLE ORIFICE CONTROL

The variable orifice is the part of the chlorinator which controls the flow of chlorine through the chlorinator. The orifice can be adjusted manually or automatically and its setting will depend on the chlorine demand in the water or wastewater process.

There are different types of orifices available, as indicated in Fig. 11-5 (a), (b) and (c).

(e) Vacuum Regulating Valve

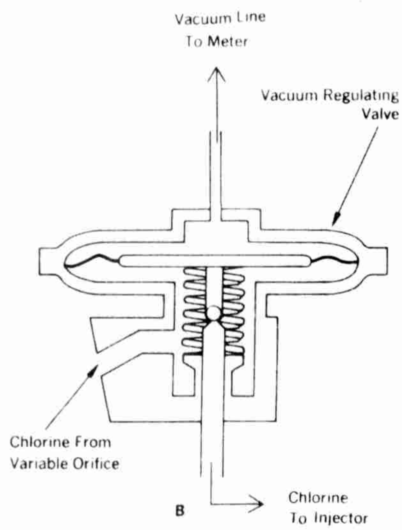


FIG. 11-6 VACUUM REGULATING VALVE

The diaphragm, spring-loaded vacuum regulating valve (Fig. 11-6) maintains the proper operating vacuum downstream of the variable orifice. Chlorine passes through the vacuum regulating valve to the injector (see Fig. 11-13 also).

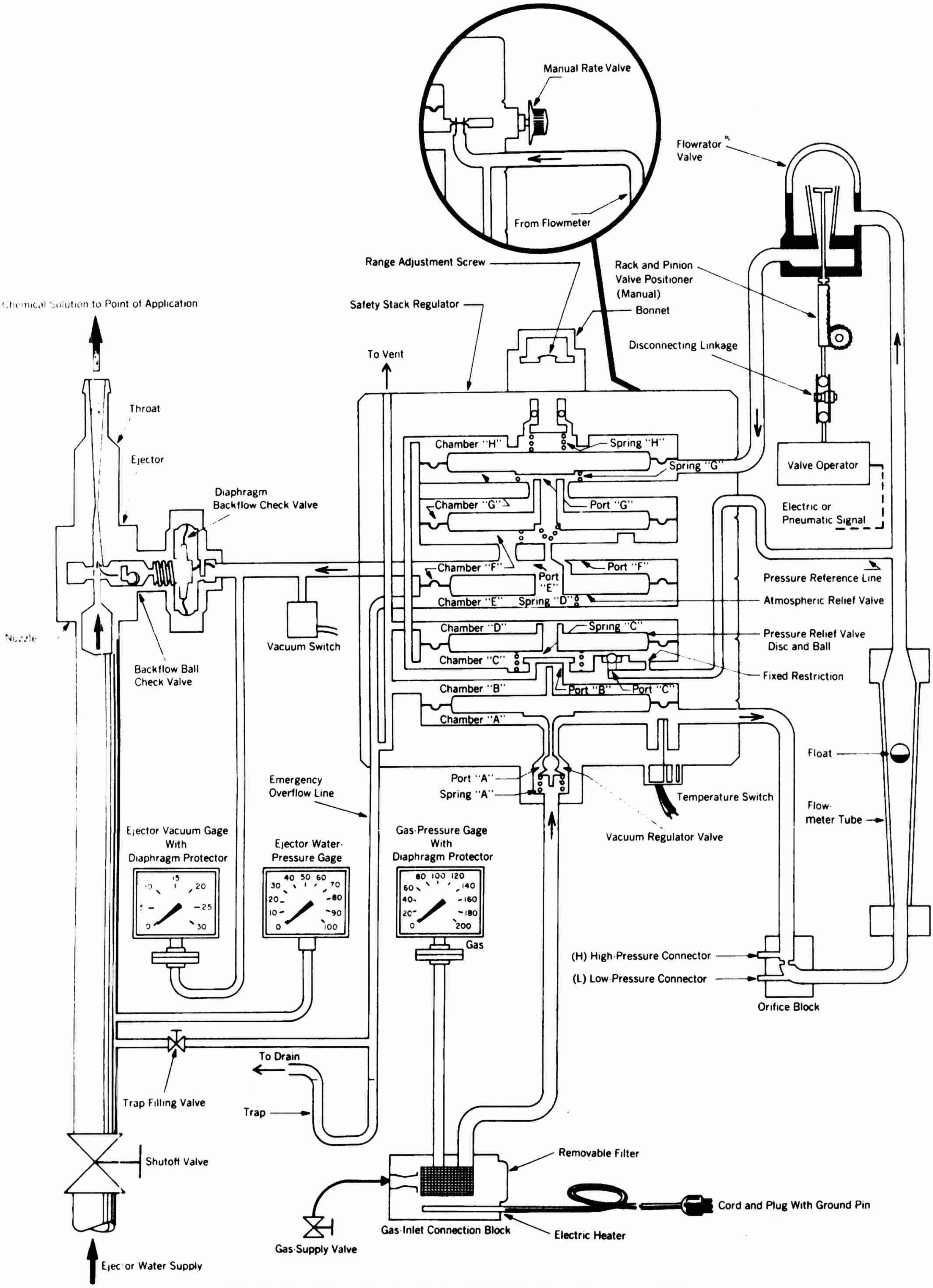


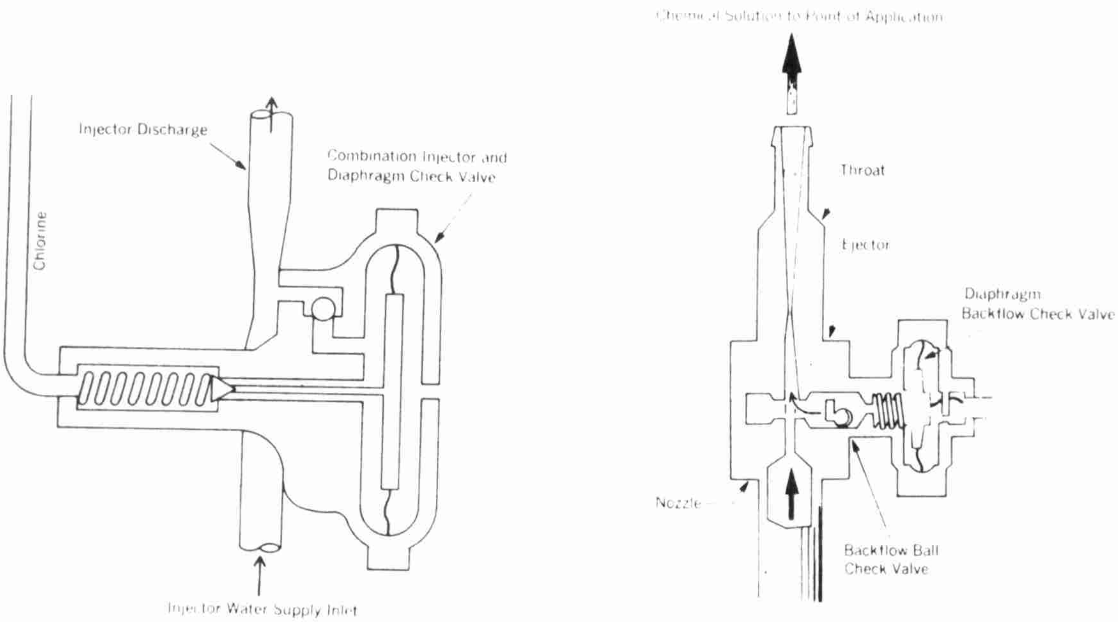
Fig. II-7. Fisher Porter Series 70-3400 Gas Dispenser With Fixed and Adjustable Range Safety-Stack Regulator

(COURTESY "FISCHER & PORTER")

NOTE:

In W&T chlorinators, the diaphragms are interchangeable. In the Fischer and Porter unit, the chlorine pressure regulating valve, the pressure-vacuum relief valve and the vacuum regulating valve form what is called a "stacked diaphragm" (see Fig. 11-7).

(f) Injector (or Ejector)



INJECTOR

EJECTOR.

FIGURE 11 - 8

The water-operated injector or ejector consists of a venturi-type nozzle and a diaphragm back-flow check valve. Water enters the venturi under high pressure, low velocity. At the "neck" or nozzle, this changes to low pressure, high velocity, thereby creating a partial vacuum. This vacuum draws chlorine gas into the venturi, and the solution of chlorine and water is then discharged to the point of application.

The injector is the first point in the process where the chlorine gas comes into contact with the water. Total mixture of the solution usually occurs at or beyond the injector discharge.

Should an accident occur while the operation is under proper vacuum, air would be drawn into the chlorinator, thus preventing chlorine from reaching the atmosphere. Negative or low pressure permits the use of lighter, corrosion-resistant plastic components. If chlorine is under high pressure, do not use plastic components.

A back-flow check valve connected to the injector is used primarily to prevent any solution from backing up into the chlorine line, leading to possible corrosion of materials (see Fig. 11-8 (a) and (b), and Fig. 11-14 and Fig. 11-15).

NOTE:

The injector may wear with time. If the raw water contains any foreign matter, a strainer should be installed in the water line to the injector. The injector does NOT have to be installed on the chlorinator but may be located wherever it is convenient.

6. Water Pressure Regulator

Used to control and maintain the water pressure at a constant value and eliminates fluctuations caused by the increase or decrease of the pressure. The installation and use of a water pressure regulator can prevent excessive wear on the injector throat and tailway, cut down on the noise caused by water flowing at very high pressures and permit a steadier operation.

The required water pressure and flow will vary with the amount of chlorine added, and also with the size of the injector.

7. Booster Pump (see Fig. 11-1)

Some chlorine installations may not have sufficient pressure at the point of application. In such instances a booster pump is installed to provide the necessary pressure to overcome friction losses and meet the pressure demands of the system.

8. Strainer Preceding the Injector (see Fig. 11-1)

It is recommended that a strainer be installed on the water line to the injector. This prevents any possible grit or foreign material from entering and blocking the injector, or causing undue wear on the injector throat and tailway.

If a booster pump is used in the system, the strainer should precede the pump (the injector comes after the pump). A "Y" type strainer is used for ease of cleaning.

The size of screen opening would depend on the size of the injector throat, as well as the foreign materials suspended in the water.

9. Valves (Excluding Chlorinator Valves) (see Fig. 11-1)

(a) Cylinder Valve (see Fig. 5-6)

Used to open or close individual cylinders.

(b) Auxiliary Valve (see Fig. 11-17 and Fig. 5-5)

At the end of flexible coil connecting to the cylinder. If the coil is left disconnected from the cylinder, the auxiliary valve must be closed. This prevents corrosion caused by any moisture accumulation in the coil.

(c) <u>Header or Manifold Valve</u> (see Fig. 11-1)

The header valve connects the flexible coil to the fixed piping, or cylinder header. It is used to isolate individual cylinders from the chlorination system. Its construction is similar to the cylinder valve, except that the header valve does not have a fusible plug.

(d) <u>Check Valve</u> (see Fig. 11-1)

Used to prevent any solution from returning or flowing back into the water line or into the chlorinator.

(e) <u>Relief Valve</u> (see Fig. 11-1)

Used to prevent any excessive build-up of pressure in the water line between the booster pump and the chlorinator.

(f) <u>Pressure Reducing Valve (PRV) in Header</u> (see Fig. 11-18)

Used primarily to control the chlorine gas pressure into the chlorinator. The PRV also helps prevent chlorine gas from changing to liquid chlorine in the line between the cylinders and the chlorinator. It should be located as close to the cylinder as possible.

10. Evaporator

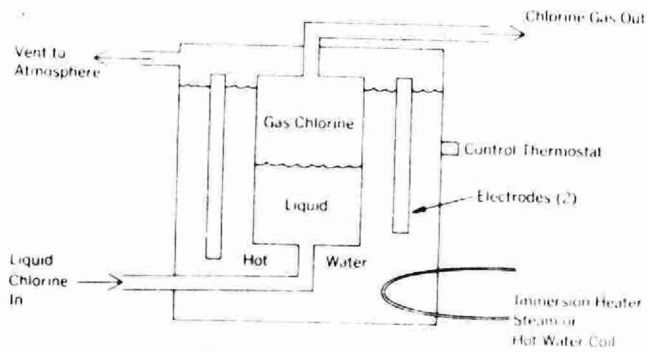


Fig. II-9. Evaporator

An evaporator changes liquid chlorine into chlorine gas at a faster rate than is obtained from a container at room temperature.

An evaporator is used with one-ton containers or tank cars, and not with 150-lb. cylinders. It is also used where large amounts of chlorine gas are required (over 400 lbs./day).

As indicated in Fig. 11-9, liquid chlorine is fed into a chlorine cylinder which is immersed in a bath of hot water. The water is heated by an immersion heater (steam, hot water or electric), and the temperature of the bath is controlled by a thermostat at approximately 160°F. The evaporation rate of liquid chlorine increases with temperature and as more liquid chlorine changes into chlorine gas, the amount of gas available increases.

11. Exhaust Fan (see Fig. 11-1)

An exhaust fan is installed in the chlorination room to prevent any accumulation of chlorine gas and to provide a specific number of air changes according to the Ministry of Labour Code. It is usually mounted near the floor level on the outside wall of the building. In some cases, the fan is mounted high on the wall or on the roof with an inlet duct going down to within 18 inches of the floor level. The duct vent must be near floor level to exhaust chlorine gas since chlorine is heavier than air and any accumulation would settle at the floor level.

The louvers and blades on the fan should be inspected regularly to ensure trouble-free operation (see Start-Up, Topic 12).

The exhaust fan switch should be located on the outside wall near the door to the chlorine room.

12. Safety Devices (see Fig. 11-16, 11-16B)

Safety devices include:

(a) alarm systems
(b) rupture discs
(c) air packs
(d) first aid kit
(e) fire fighting equipment

(a) Alarm Systems (Chlorine Detection)

In chlorination, alarm systems are used primarily to warn the operator that chlorine is escaping or of an equipment failure or malfunction. Alarm systems can also be used to send local or remote signals, or to activate other equipment (for example, standby equipment, exhaust fans). The most common systems in use to detect chlorine in the atmosphere are sensitized paper* and a sensing cell system.

Sensitized paper (see Fig. 11-16) is darkened in the presence of chlorine. Its method of operation is as follows. A photo-electric cell picks up the reflected light from the sensitized paper. This is converted to an electrical current which opens a relay circuit to the alarm. When the sensitized paper is darkened in the presence of chlorine, the current to the relay drops. This closes the relay circuit and activates the alarm system.

A sample of air is constantly pumped across the sensitized paper. The paper should be replaced daily, or whenever an alarm condition exists. Normal shelf life of the paper is approximately six months.

* *The sensitized paper detector has recently been taken off the market. However, the supply of sensitized paper will continue to be available.*

In the *sensing cell system*, a sample of air is drawn through a sensing cell. Any chlorine present in the air sample will increase the electric signal to an alarm circuit. When the electric signal reaches a pre-set point, the alarm system is activated and remains activated until the chlorine leak is repaired and chlorine is no longer present in the air sample. The electric signal generated by the sensing cell is reduced and the alarm circuit is deactivated.

When equipment failure or malfunction occurs, the alarm system is activated by the vacuum within the chlorinator. If the vacuum *increases* beyond the normal operating level, a diaphragm-operated switch activates the alarm system. Vacuum increase is caused by failure of the chlorine supply.

If the vacuum should *decrease* or drop below the normal operating level, the diaphragm-operated switch will activate the alarm system. Vacuum decrease can be caused by failure of the water supply, plugging of injector, increase in pressure downstream of the injector, or any leak in the vacuum system.

(b) Rupture Discs

A rupture disc is used on the larger installations, such as ton containers or tank cars. The disc is designed to protect the equipment and will rupture (break) when the

gas pressure in the chlorine manifold system reaches a pre-determined value greater than normal operating pressure, but less than maximum allowable pressure. A typical installation is as follows:

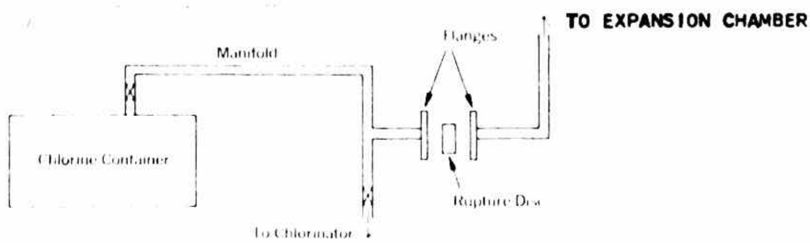


Fig. 11-10 Rupture Disc

The rupture disc is placed between two flanges in the line to an expansion chamber. This line comes off the manifold between the chlorine container and the evaporator or chlorinator.

(c) Air Packs

An air pack is a breathing apparatus located *OUTSIDE* the chlorine room and used by the operator when entering the room if a chlorine leak is suspected or present.

(d) First Aid Kit

A complete first aid kit is a must for every plant. When used, articles should be replaced as quickly as possible.

(e) Fire Fighting Equipment

Check extinguishers regularly. The Fire Department telephone number should be posted by the telephone.

13. Recording Charts and Pens (see Figs. 11-19 and 11-20)

A recording chart is used to record the daily consumption of chlorine. When positioned, the chart must be free to move, and not binding in any way. When changing charts, always check the time to make sure the chlorine consumption is recorded at the proper hour on the chart.

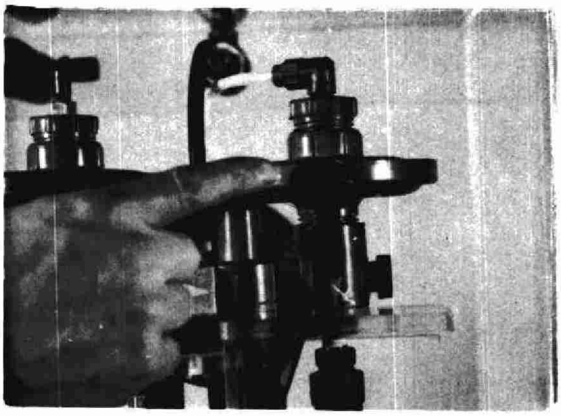
Chart pens are supplied with ink by (a) capillary tube or (b) trough type pen.

(a) The *capillary tube* has a double effect: it cleans the tube while loading the pen.

(b) The *trough type* pen should be cleaned of all congealed ink at regular intervals and should be replaced when the tips of the pen become worn.

14. Compressors

Compressors used for air control signals must be maintained to produce a clean, moisture-controlled air supply to the instrument. For trouble-free operation of the recorders, the air should pass through a filtering cell to remove suspended oil and dust particles, and a drying unit to remove moisture.



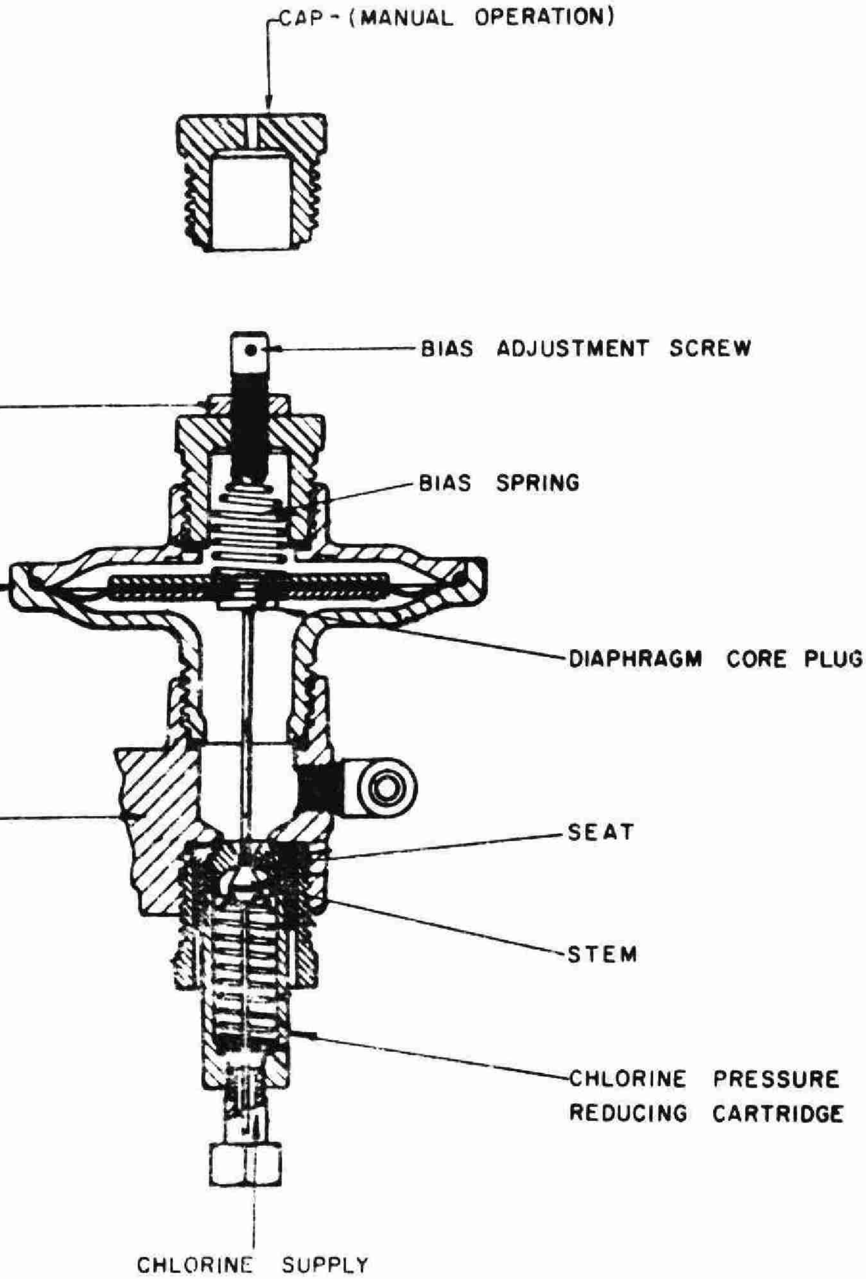
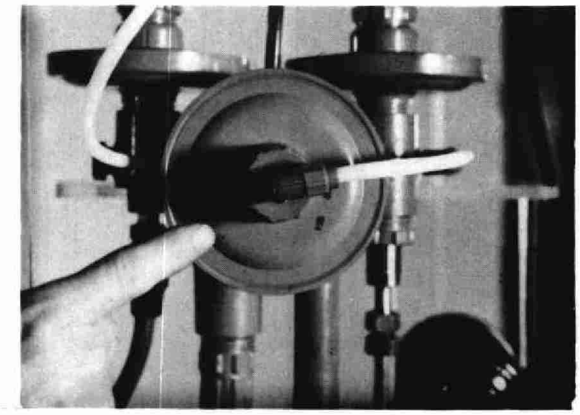


FIG . II- II. CHLORINE PRESSURE REDUCING VALVE



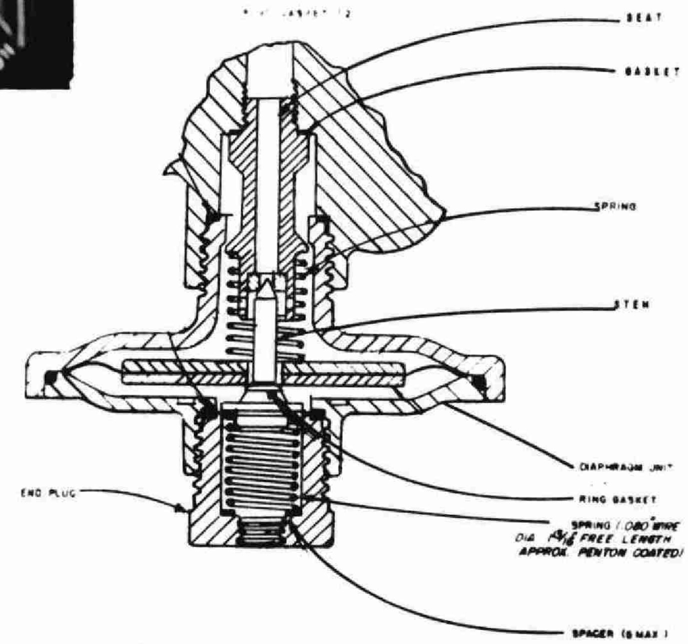
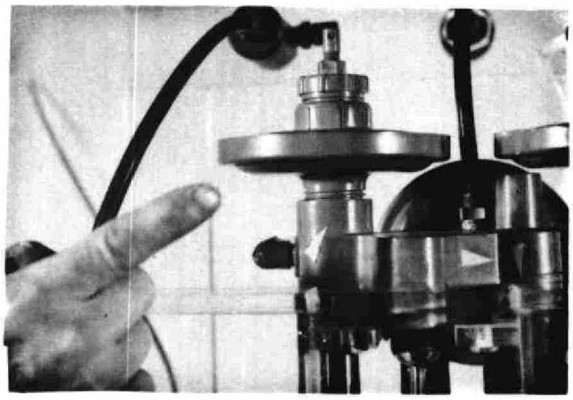


FIG: 11- 12. VACUUM & PRESSURE RELIEF VALVE.

USED IN 400 LB CAPACITY V- NOTCH CHLORINATOR



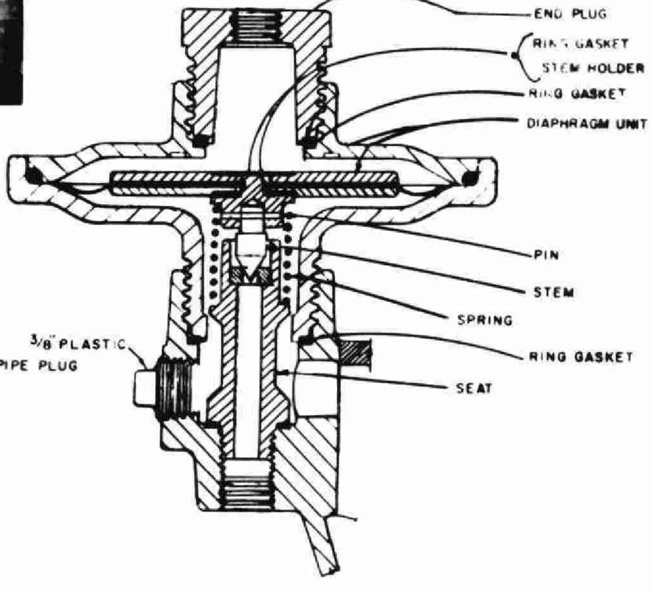
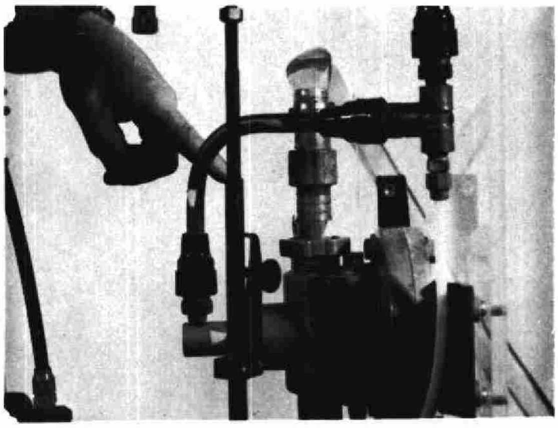


FIG 11-13 VACUUM REGULATING VALVE

USED IN 400 LB. CAPACITY V- NOTCH CHLORINATOR



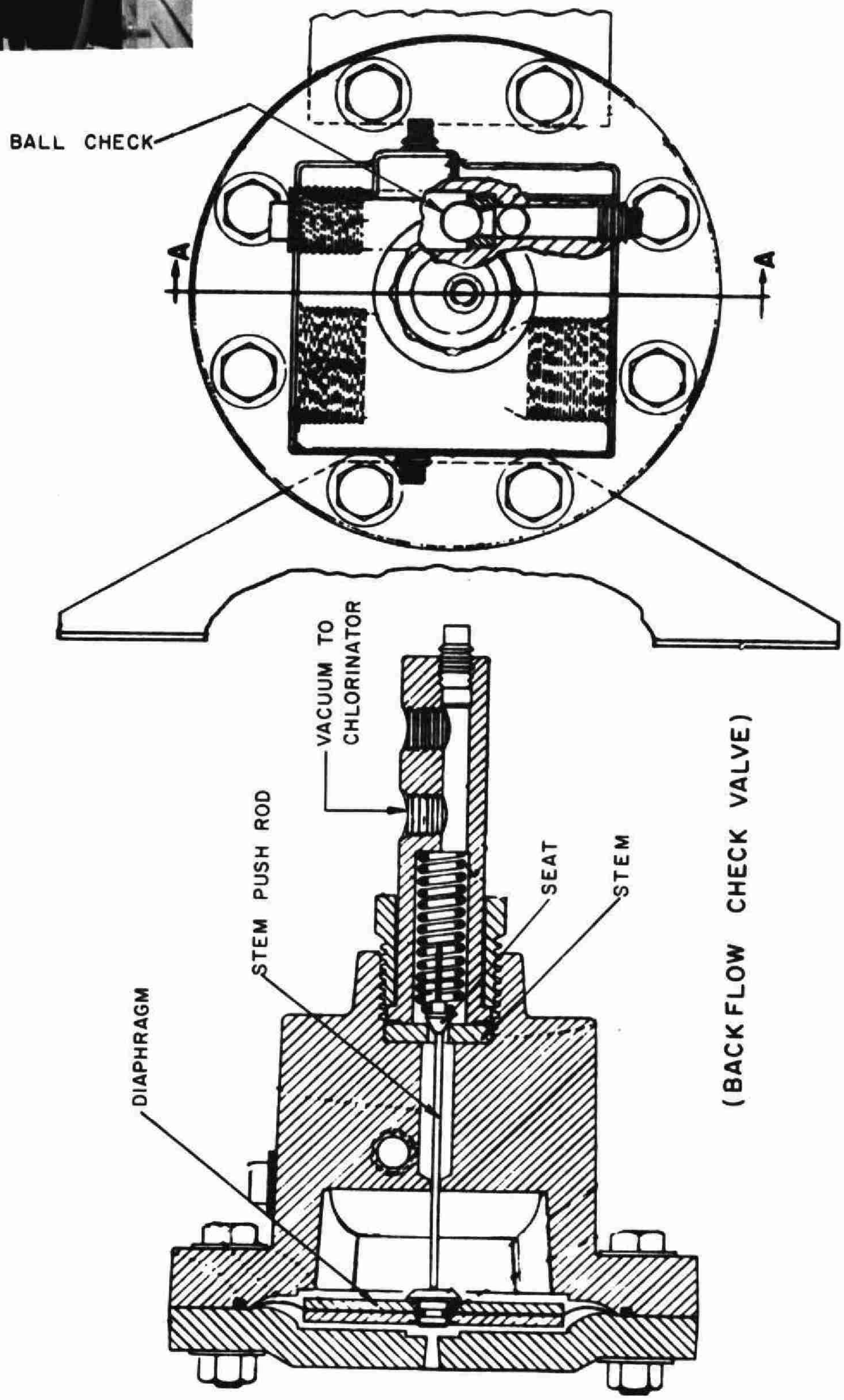
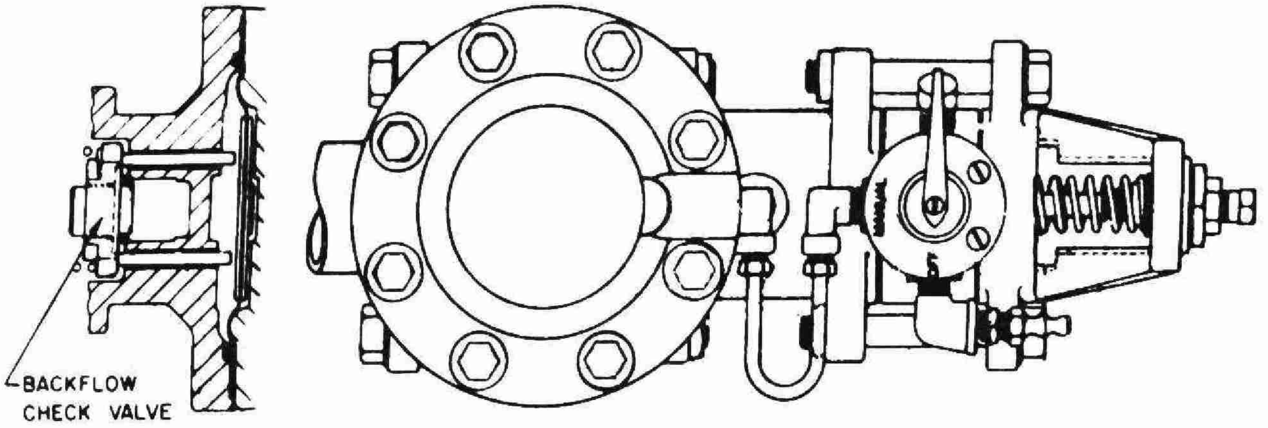
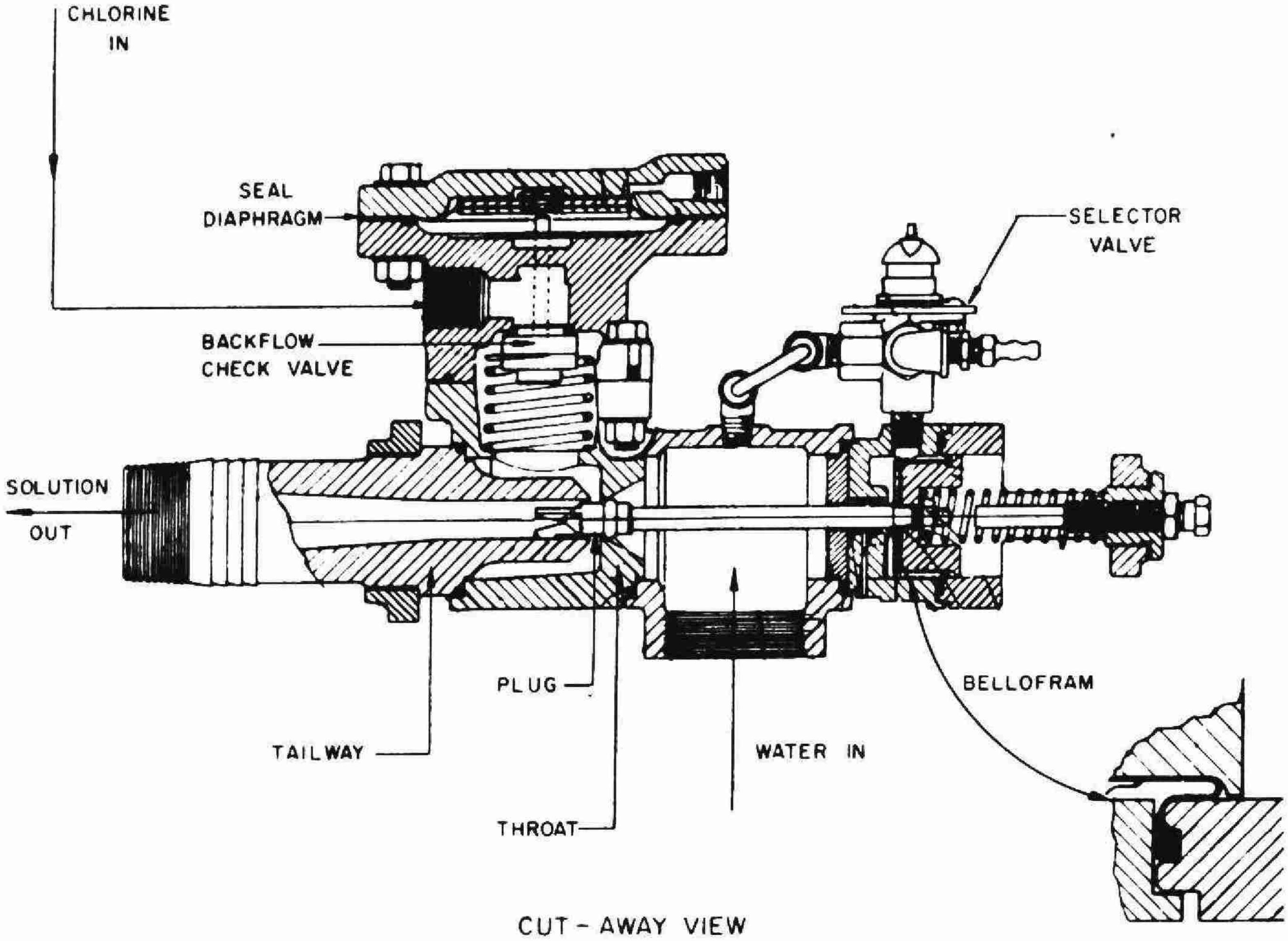


FIG: II-14. INJECTOR BODY.

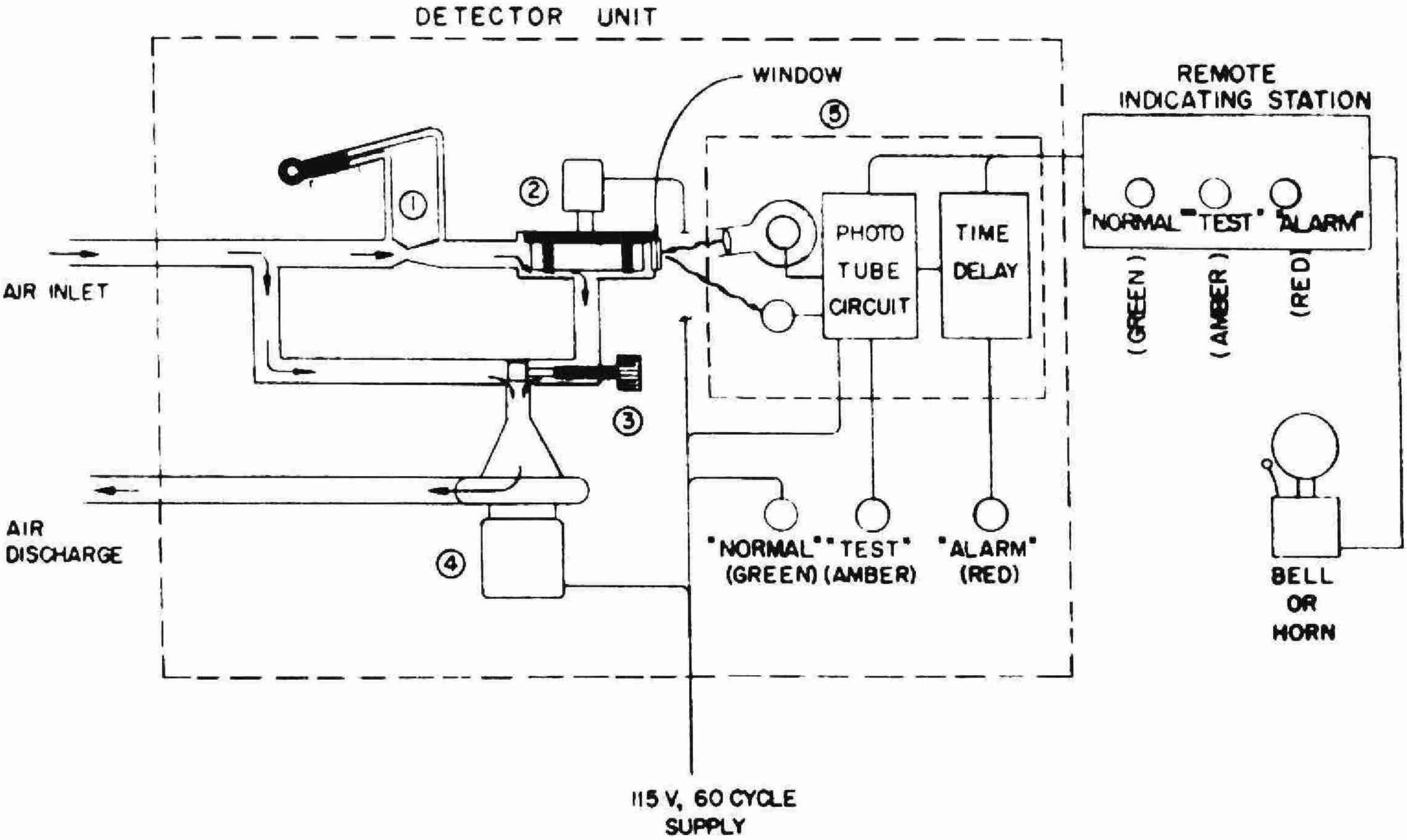


GENERAL VIEW



CUT - AWAY VIEW

FIG. 11-15 INJECTOR - PILOT OR MANUALLY OPERATED



NOMENCLATURE

① AIR SAMPLE MEASURING ORIFICE & MANOMETER
② TEST CHAMBER WITH SENSITIVE TEST PAPER MOUNTED ON ½ RPM REVOLVING DRUM TEST CHAMBER IS EQUIPPED WITH WINDOW FOR PHOTOTUBE AND DOOR FOR ACCESS TO TEST PAPER WHICH MUST BE CHANGED DAILY
③ AIR SAMPLE FLOW ADJUSTMENT SET FOR 03 TO 04 CFM AIR FLOW THROUGH TEST CHAMBER
④ BLOWER
⑤ PHOTOTUBE AMPLIFIER CHASSIS WITH LIGHT SOURCE AND TIME DELAY CIRCUITS

FIG. 11-16. ALARM SYSTEM USING SENSTIZED PAPER.

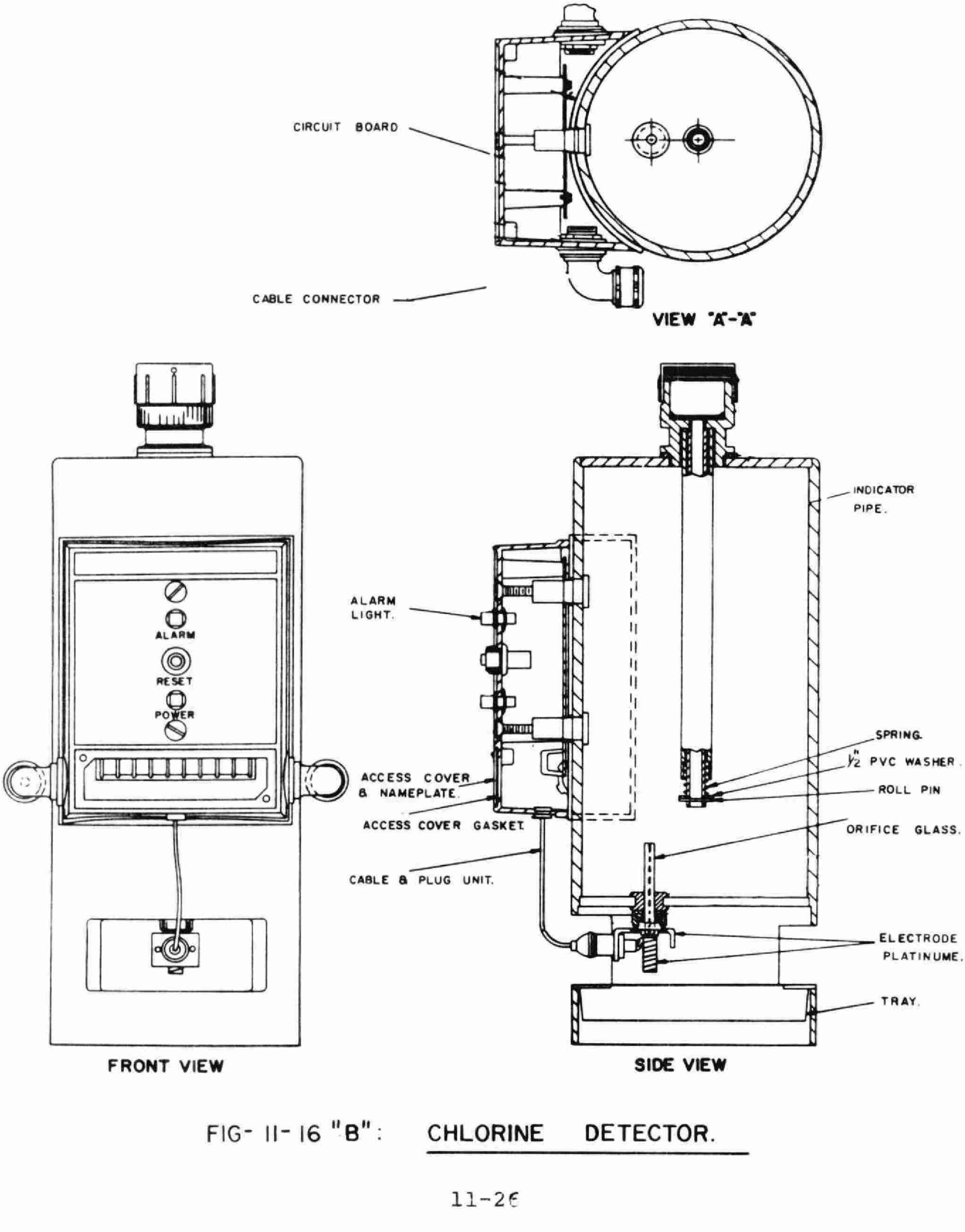
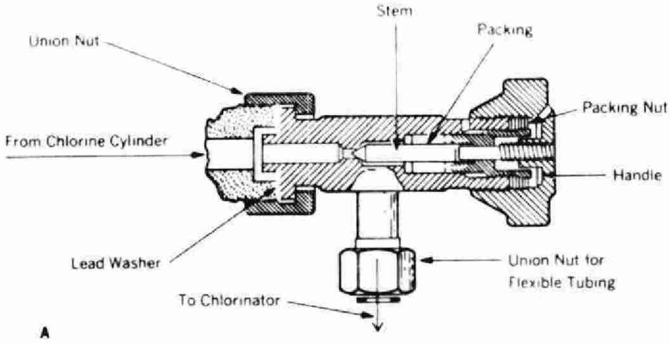


FIG- II- 16 "B": CHLORINE DETECTOR.



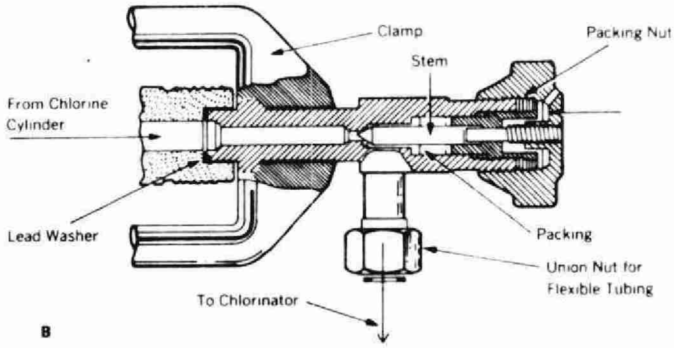


FIGURE 11 - 17 AUXILLARY CYLINDER VALVE
A) SCREWED TYPE (UPPER)
B), CLAMPED TYPE (LOWER)

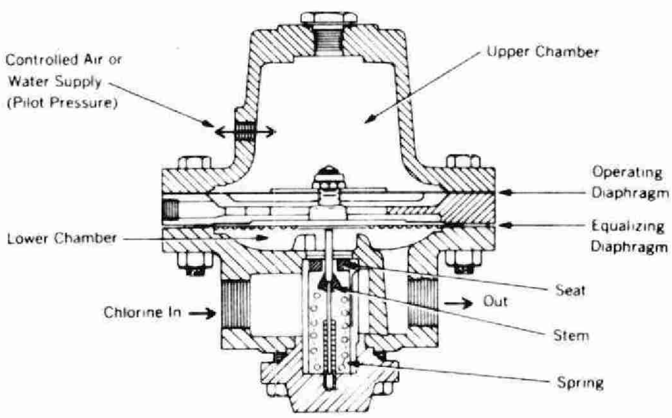
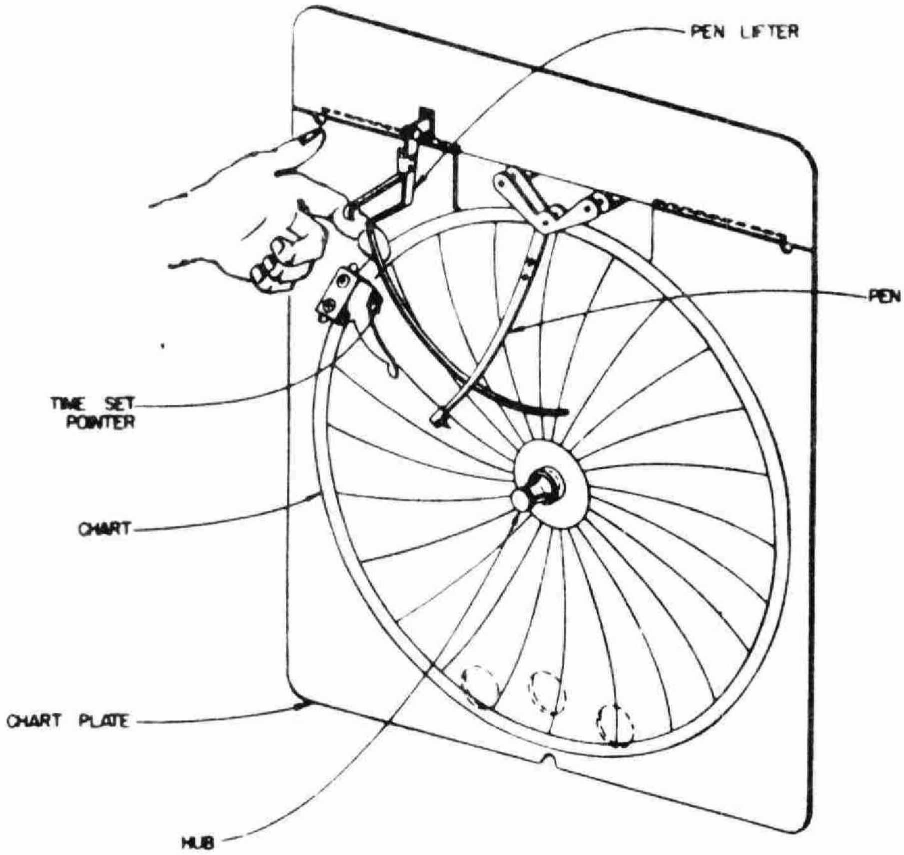


FIGURE 11 - 18 CHLORINE PRESSURE REDUCING VALVE
PILOT OPERATED - (AIR OR WATER)

(1) RAISE THE PEN LIFTER.

(2) PULL OUT ON THE CHART HUB. IT WILL COLLAPSE INTO ITSELF, LEAVING THE CHART FREE TO COME OFF. REMOVE THE CHART.

(3) PUT ON A NEW CHART. PUSH IN ON THE CHART HUB SO THAT IT REENGAGES THE CHART.



(4) ROTATE THE CHART HUB UNTIL THE PROPER TIME ARC IS INDICATED BY THE TIME SET POINTER. (NOTE---DAY AND NIGHT SECTIONS ON THE CHART) THE TIME SET POINTER AND THE PEN POINT REGISTER ON THE SAME TIME ARC.

FIG. II-19. CHART PLATE FEATURES.

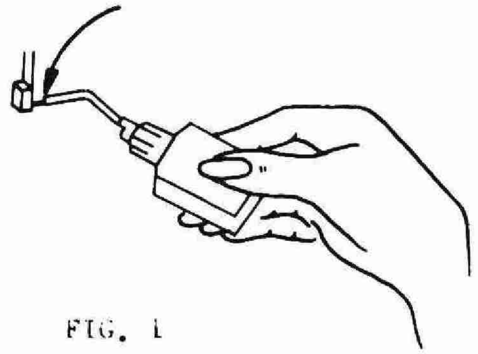


FIG. 1

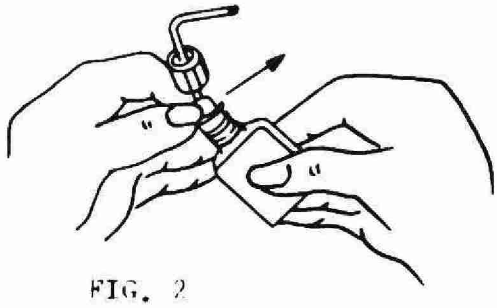


FIG. 2

TO INK A BOX PEN

Fill through the tip with the plastic ink bottle as shown in Fig. 1. This method of filling insures against air bubbles or other obstruction, and also primes the pen for quick starting. Put in mo more ink than is estimated necessary. If there is doubt, a clean pen may be filled full the first time, but after that, the ink level should be kept as low as possible for cleanest lines and shortest drying time.

After using the plastic ink bottle wipe the spout and replace it tightly in the sealing hole in the bottle cap.

STARTING A STUBBORN BOX PEN

If trouble is encountered in getting a box pen to ink, proceed as follows:

1. Remove the pen from the pen-arm. To do this, hold the pen-arm firmly and turn the pen in a counterclockwise direction permitting the clip on the back of the pen to be slipped off the pen-arm. Carefully withdraw the pen from the hole in the pen-arm.
2. Fill the pen nearly full of ink.
3. Grasp the pen reservoir with the thumb on top and fore-finger beneath, and squeeze. Ink should start to ooze from the pen tip.

MAINTENANCE OF PEN

If the pen becomes dirty or begins to skip, clean it as described below. Detergent cleaners may be used, but every trace should be removed or severe feathering may result. Use only recorder ink. If long service wears a pen so that the line is too wide, replace the pen.

TO CLEAN A CLOGGED BOX PEN

1. Remove the box pen from its pen-arm. To do this, hold the pen-arm firmly and turn the pen in a counterclockwise direction This permits the clip on the back of the pen to be slipped off the pen-arm. Carefully withdraw the pen from the hole in the pen-arm.
2. Run a wire not larger than 0.005" diameter (B&S Gauge #36 or higher) or a Cleaning Wire, Part P-26488, through the tip to push out the dried ink.
3. Flush out by filling through the tip with the plastic ink bottle. Force through a surplus of ink into a tissue or paper towel to make sure the tip is clean.
4. Replace the pen.

TO REFILL THE PLASTIC INK BOTTLE

1. Pull out the spout and remove the screw cap as shown in Fig. 2.
2. Force the plug sideways, up and out. Don't try to pull it straight.
3. Fill to the line. Replace plug, cap and spout.

FIG. 11-20 Instructions for Box Pen W&T Recorders

SUBJECT: CHLORINATION EQUIPMENT

TOPIC: 12 START-UP

OBJECTIVES:

Trainee will be able to:

1. Demonstrate start-up of chlorination system;

2. Perform the following steps in proper sequence:

   (a) start vent fan

   (b) open water lines

   (c) check chlorinator vacuum

   (d) open cylinder and valves

   (e) check for leaks

START-UP DETAILS

(1) Push button to start exhaust fan:

(a) check louvers (especially in winter) to make sure they are open.

(b) if there is ductwork for externally-mounted fan, check for air flow by placing hand on end of duct for suction.

(c) if there is no suction: (i) check to see if FAN is running; (ii) check ductwork for blockage.

NOTE: *Exhaust system (fan and motor) MUST be in operation at all times during start-up.*

(2) Check visually the following pipelines and ensure that equipment is hooked up:

(a) water lines: check piping, elbows, valves, tees.

(b) chlorination lines: check piping, elbows, valves, tees.

(c) vent lines: be sure they are not plugged; vent lines must go to OUTSIDE atmosphere and should have a screen over the outlet.

(d) automatic control lines (if any): purge lines for possible moisture accumulation; in vacuum or pneumatic system, purge all air from pressure differential systems.

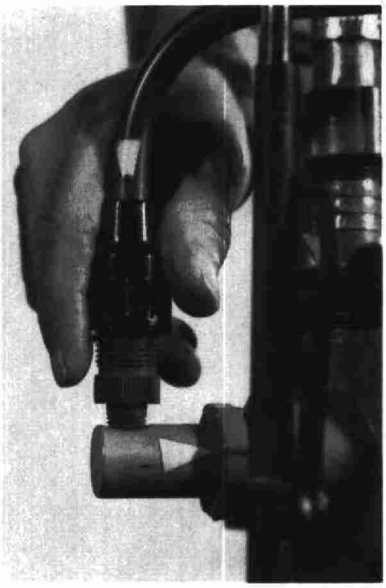


Fig. 12-1 Unscrew (by hand) fitting in injector vacuum line.

Fig. 12-2 Lift tubing from fitting.

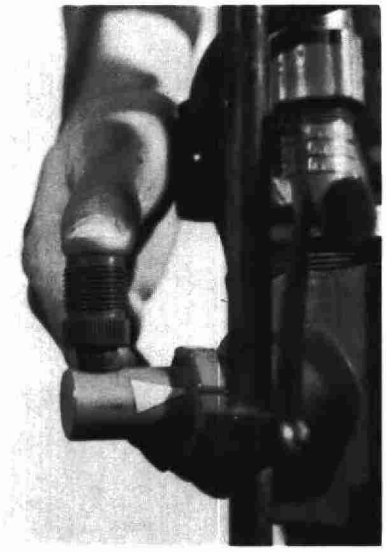


Fig. 12-3 Place thumb over hole in fitting, hold for a moment.

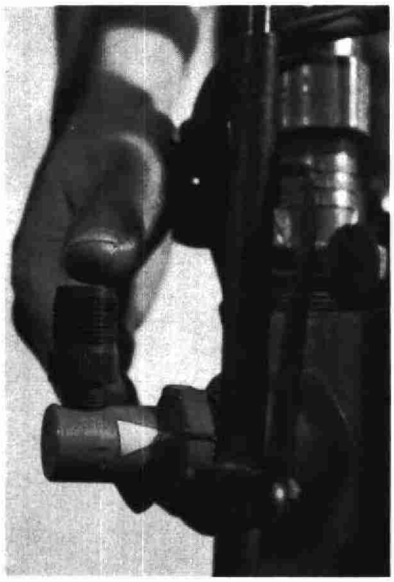


Fig. 12-4 Release thumb and listen for "pop" caused by vacuum. Reconnect tubing.

(e) electric lines: make sure they are plugged into sockets.

(f) new chlorine lines: use litharge and glycerine or teflon tape on pipe joints.

(3) Open valve for water supply:

(a) listen for water "whistling" through injector.

(b) if no sound of water through injector, check water supply upstream.

(4) Visually check the following for leaks:

(a) valves,

(b) elbows,

(c) piping,

(d) connections,

(e) if no leaks are apparent, proceed to Step 5.

(5) Check to see if vacuum is obtained (see Figs. 12-1 to 12-4):

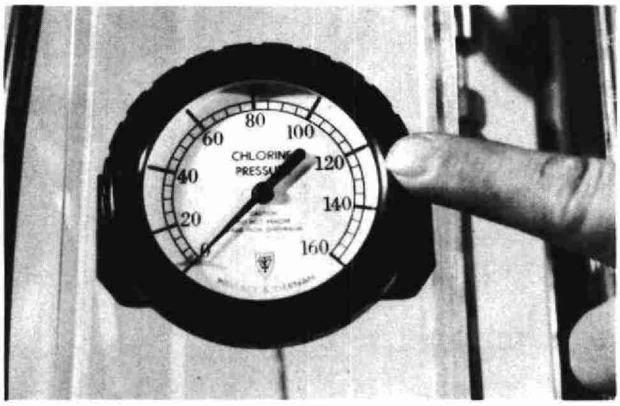
(a) look at the vacuum gauge (if supplied) on the chlorinator; it should indicate a *vacuum* reading.

(b) if there is no vacuum (or if no gauge is supplied), disconnect vacuum line at the injector.

START UP - CHECK FOR LEAKS

Fig. 12-5

Check chlorine pressure gauge for pressure.



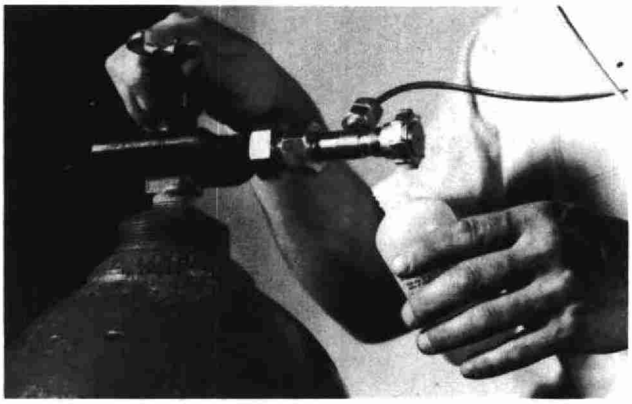
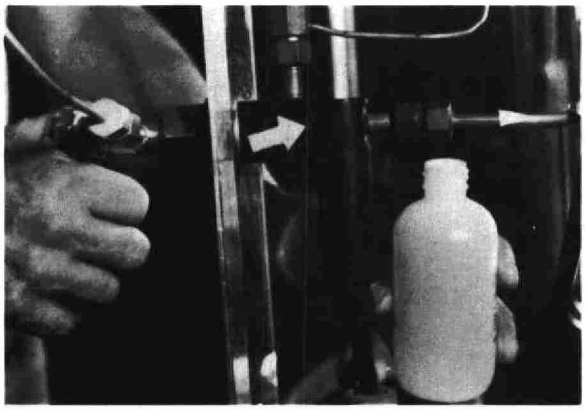


Fig. 12-6

Crack open cylinder valve, check for leaks at all joints with ammonia vapour.

Fig. 12-7

Check for leaks in chlorinator by using ammonia vapour.



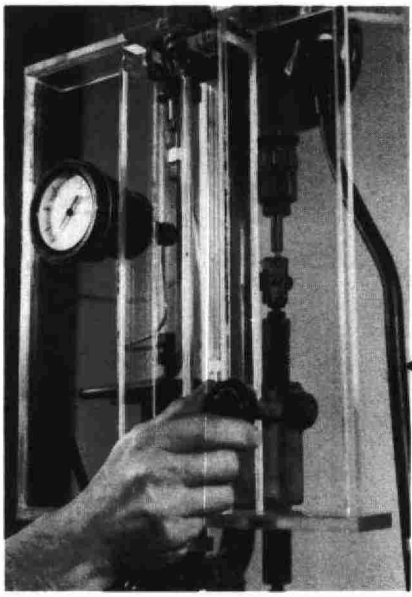
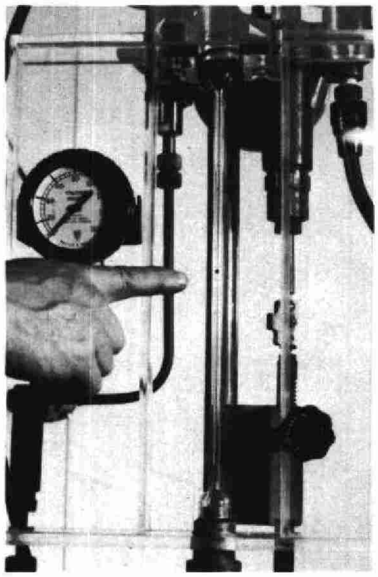


Fig. 12-8

If no leaks, adjust feed rate.

Fig. 12-9

Check ball in rotameter for feed rate setting.



(c) place finger over injector connection. If there is suction, it means there is vacuum.

(6) Check and be sure that *ALL* valves between the chlorinator and cylinder(s) are *OPEN*. Turn handle to open as indicated on valve.

WHY? To ensure purging of system in case of leaks.

(7) Turn chlorinator feed control to any open position.

(8) Open cylinder valve and check chlorine pressure gauge (see Fig. 12-5):

Simply "crack open" at beginning.

WHY? If there is a bad leak in the system, the valve can be shut off faster.

NOTE: *Valve may be stiff to open. A quick, sharp blow may be required, using butt of hand to open valve.*

(9) Turn chlorinator feed control to *CLOSED* position and observe chlorine pressure on gauge.

(10) Check for chlorine leaks (see Figs. 12-6 and 12-7):

Open a concentrated ammonia bottle and check all joints and piping on chlorine line *by holding bottle*

under or close to chlorine joints and piping (a plastic squeeze bottle to exhaust ammonia vapour).

NOTE: A cloud of white smoke will indicate chlorine leak (caused by chlorine reacting with ammonia).

(11) *If any leaks are found:*

(a) shut cylinder valve immediately.

(b) turn chlorinator feed control to MAXIMUM to purge system.

(c) *leave chlorinator room and shut door* until pressure gauge reads ZERO (usually a window in the wall allows you to see this from outside) and fumes are exhausted to atmosphere.

(d) when pressure gauge reads ZERO, proceed with corrective maintenance for leak(s). (This may be tightening of joint, replacing leaky gasket, replacing valve, replacing split piece of pipe, etc.)

(12) When leak has been repaired:

(a) fully open the chlorine cylinder valve (1 1/2 turns).

(b) *RETURN TO STEP 4 AND REPEAT STEPS 4 TO 11.*

(13) *If no leaks are found:*

Adjust the chlorinator setting to the desired rate (see Figs. 12-8, 12-9).

(14) If chlorination system is MANUAL, then check-out is complete.

(15) If chlorination system is AUTOMATIC, check control components for proper functioning according to the manufacturer's specifications.

NOTE: *Loosen and tighten diaphragms BY HAND only (see Figs. 12-10, 12-11).*

TABLE No. 12-1

SUMMARY: START-UP SEQUENCE
1. Start vent fan
2. Open water lines
3. Check chlorinator vacuum
4. Open cylinder and valves
5. Check for leaks

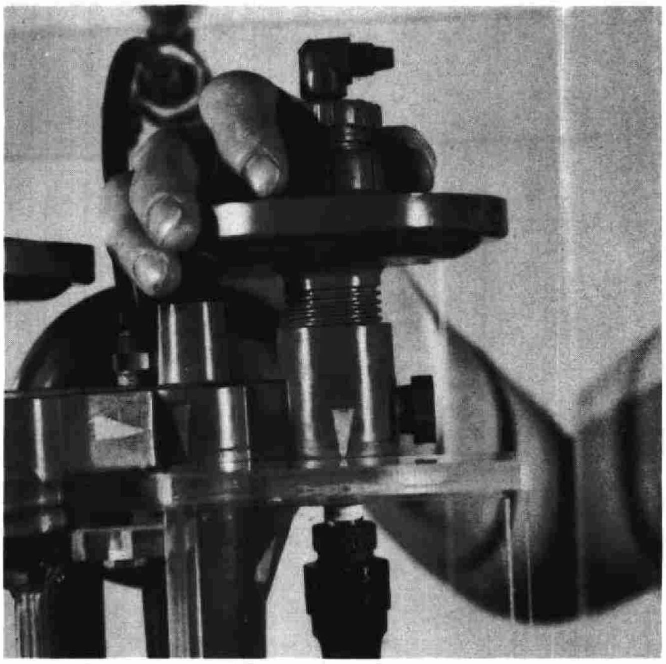


Fig. 12-10 Loosen and tighten DIAPHRAGMS by hand only.

Fig. 12-11 Lifting DIAPHRAGM from head assembly.

SUBJECT:

CHLORINATION EQUIPMENT

TOPIC: 13

NORMAL OPERATION OF SYSTEMS

OBJECTIVES:

Trainee will describe the normal operation of the following chlorination systems:

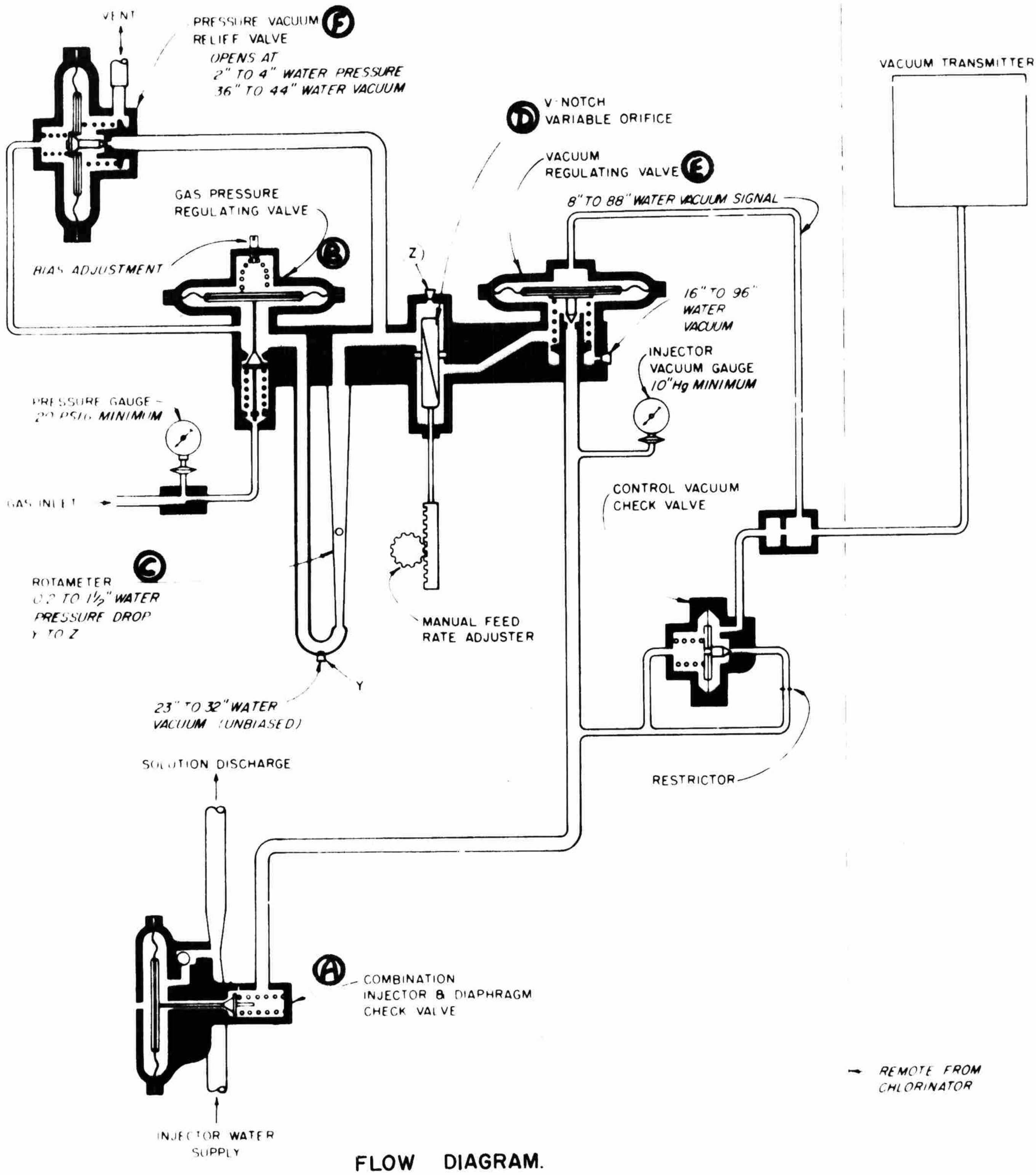
1. Wallace & Tiernan (W&T) variable vacuum chlorinator;

2. Advance chlorinator;

3. Wallace & Tiernan (W&T) Bell Jar chlorinator;

4. BIF Industries chlorine feeder;

5. Fischer & Porter gas dispenser.



FLOW DIAGRAM.

FIG: 13-1. VARIABLE VACUUM CONTROL VACUUM FROM MAIN INJECTOR

V- NOTCH CHLORINATOR - SERIES A- 731

NORMAL OPERATION

1. Wallace & Tiernan (W&T) Variable Vacuum Chlorinator (see Fig. 13-1)

A controlled vacuum is developed by an injector (A), allowing the chlorine gas to enter the chlorinator through a spring-loaded, diaphragm-operated pressure regulating valve (B). This valve maintains the proper operating vacuum ahead of the variable orifice (D).

The gas then flows through a rate of feed indicator (C), by-passes a combination vacuum and pressure relief valve (F), passes through the variable orifice (D), and finally through a vacuum regulating valve (E), which maintains the proper operating vacuum downstream of the variable orifice.

The gas then passes to the injector (A) where it is dissolved in water. The resultant solution is discharged from the injector to the point of application via a solution tube or diffuser. The feed rate is adjusted by changing the area of the variable orifice. This is accomplished by positioning the control plug (V-notch) within the seat.

The chlorine pressure regulating valve, which regulates the vacuum ahead of the metering orifice, also shuts off the chlorine if interruption of the injector water supply should destroy the operating vacuum, or a leak should develop in the vacuum line. Intermittent start-stop or program operation is obtained by interrupting the injector water supply.

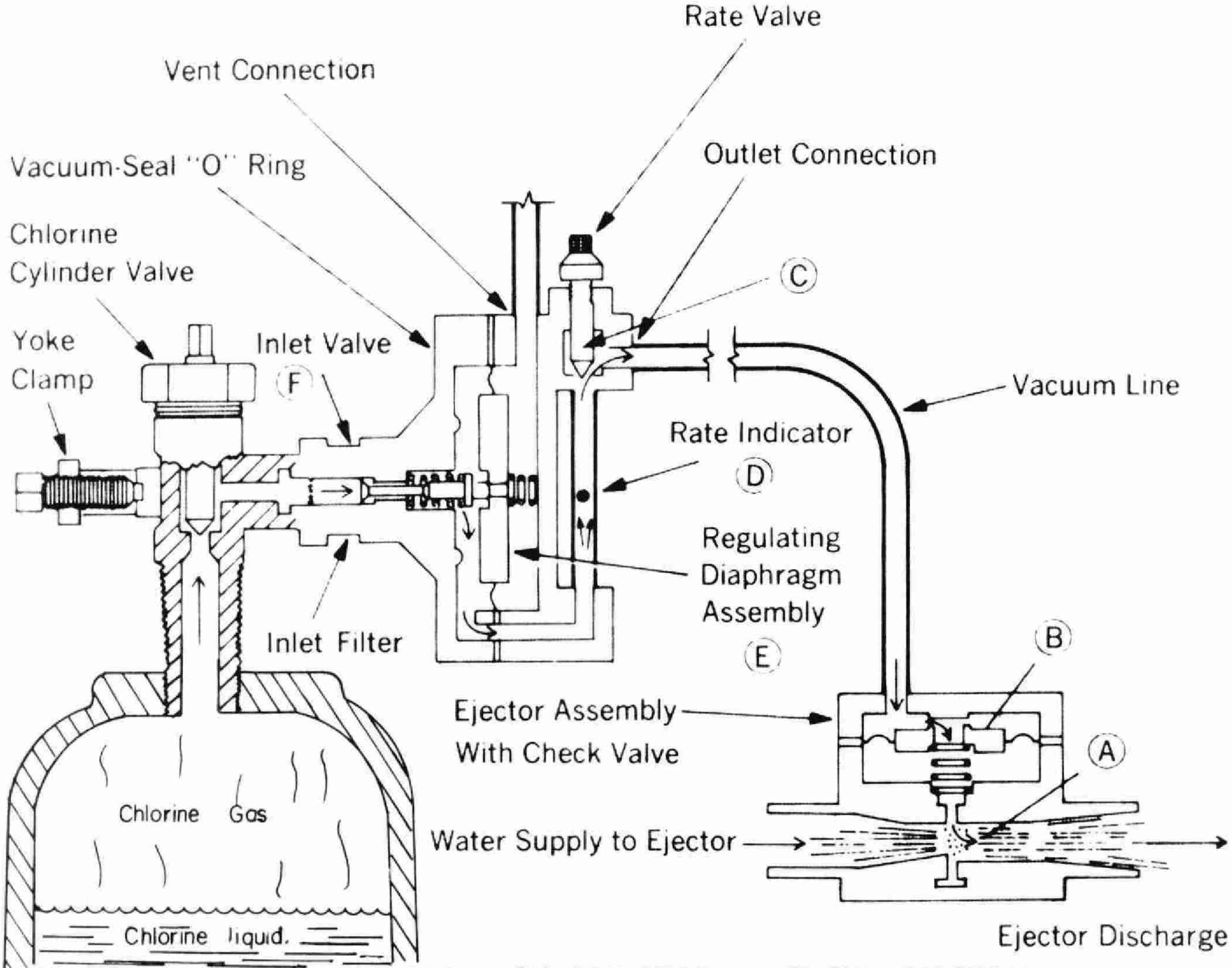


FIG. 13-2. ADVANCE GAS CHLORINATOR FLOW DIAGRAM

2. Advance Chlorinator (see Fig. 13-2)

Water passing through the injector under pressure at point (A) forms a vacuum and causes diaphragm (B) to be pulled away from the seat. This allows the vacuum to be transmitted to the rate valve (C). If the rate valve is open, the vacuum is transmitted through the rate indicator (D) to the regulating assembly (E). This pulls the regulating diaphragm in regulating assembly (E) towards the chlorine inlet valve (F), opening it and allowing chlorine gas to enter the system and pass through (E), (D), (C), (B) to (A) where it is mixed with water and discharged to the point of application.

Vacuum failure allows the spring on the inlet valve (F) to move the diaphragm (E) away from the valve (F), closing valve (F) and stopping the flow of chlorine.

If valve (F) should "stick" in the open position, diaphragm (E) would be forced away from the stem of valve (F) and chlorine would pass through the centre of diaphragm (E) and out through the vent connection to the atmosphere.

3. Wallace & Tiernan (W&T) Bell Jar Chlorinator (see Fig. 13-3)

The auxiliary water supply (A) on the bell jar chlorinator supplies the water for the tray, the collecting box and the air vacuum control assembly.

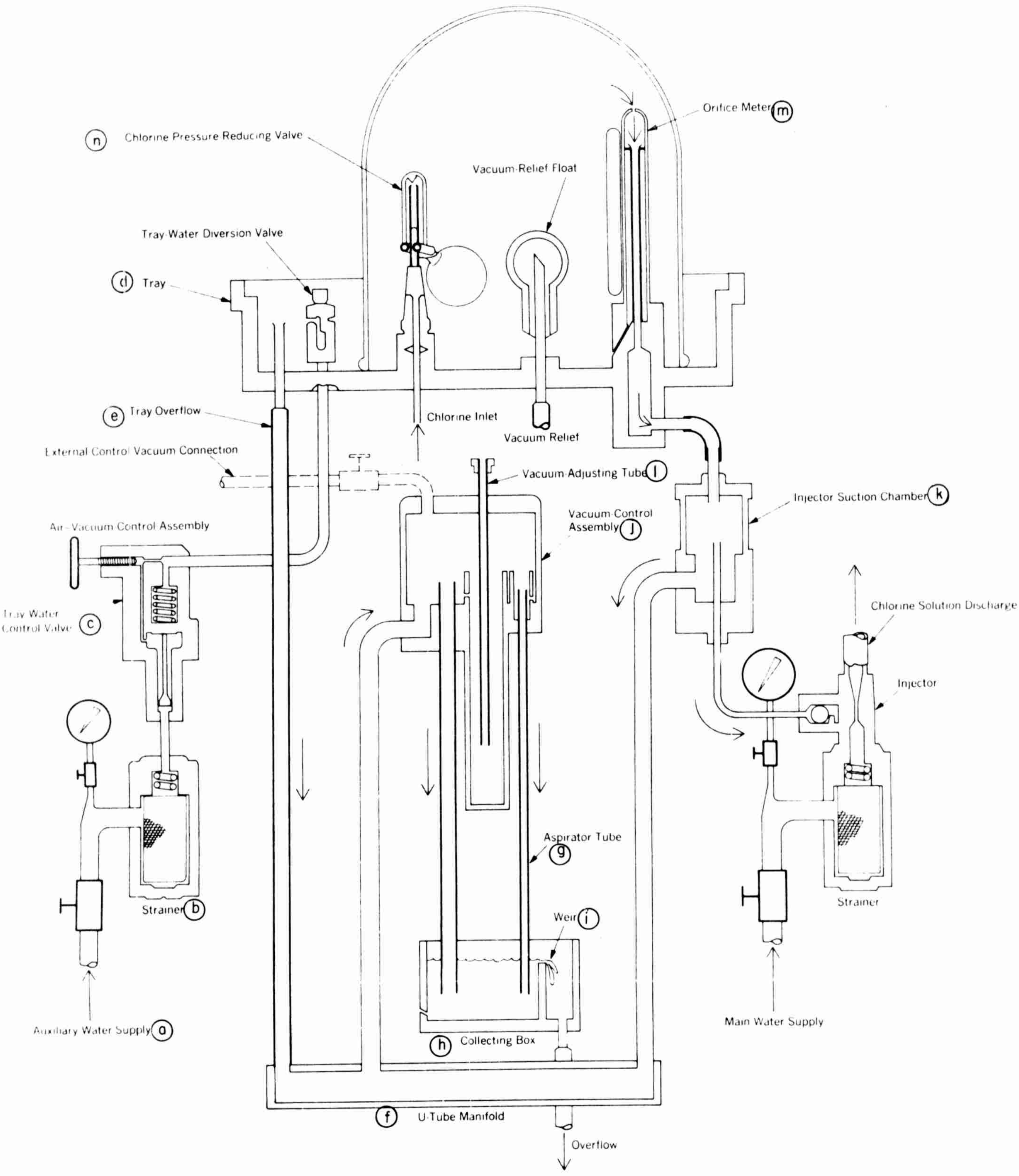


FIG: 13 - 3. Variable- Vacuum Control: Trouble-Shooting Scheme for Chlorinators.

After passing through the strainer (B), the water enters the unit through the tray water control valve (C). It passes to the tray (D), filling the tray to the top of the tray overflow (E).

From the tray overflow, the water fills up the U-tube manifold (F), and the air vacuum control assembly until it flows out through the aspirator tube (G) and overflows into the collecting box (H).

The end of the overflow tube and the aspirator tube are below the level of the weir (I) over which the water must flow to drain, and provide a seal for the vacuum control assembly (J).

The aspirator assembly pulls air from the control assembly by forming a vortex, giving a vacuum which controls the level of water in the vacuum control chamber (see above), and is transmitted through the U-tube manifold to the injector suction chamber (K).

The vacuum in the control chamber is controlled by the depth to which the vacuum adjusting tube (L) is lowered in the chamber. This allows more or less water to pass out of the suction chamber to the injector to satisfy the injector vacuum.

The resulting vacuum is then transmitted through the orifice meter (M) to the inside of the bell jar and is indicated on the meter.

The vacuum in the bell jar pulls the water up until it raises the float on the chlorine pressure reducing valve (N), lifting the needle valve off its seat and allowing chlorine to enter the bell jar. The greater the controlled vacuum, the higher the float is raised. More chlorine then enters the unit and is pulled through the orifice meter to the injector.

Adjustments for W&T Bell Jar Chlorinator

Tray Water Diversion Valve (O)

Normally set to split the flow between the two chambers. When water is extremely cold it is advisable to direct all the water *away* from the bell jar. This allows the water within the bell jar to warm up and helps prevent icing of the chlorine pressure reducing valve.

Chlorine Pressure Reducing Valve (CPRV) (N)

Is adjustable vertically. This is to adjust the water level in the bell jar to the zero line on the orifice meter (usually even with the top of the tray).

Tray Water Control Valve (C)

With the vacuum adjusting tube lifted clear of the water in the control assembly, and the machine

thus using the maximum amount of water through the injector suction tube, adjust the control valve so that there is a small flow of water over the weir of the collecting box.

Safety Controls for W&T Bell Jar Chlorinator

Injector failure causes loss of vacuum in the bell jar, allowing the water level to drop, lowering the ball on the CPRV, and closing off the chlorine.

Chlorine supply failure causes the water level to increase approximately 1 1/2 inches in the bell jar, pulling air from the atmosphere into the bell jar from under the vacuum relief float.

Leaking CPRV forces water *inside* the bell jar down to a level approximately one inch below the water level *outside* the bell jar and below the bottom of the vacuum relief float. This allows the gas to pass inside the float and out to the atmosphere.

4. BIF Industries Chlorine Feeder (see Fig. 13-4)

Water pressure passing through the injector at point (A) forms a vacuum which draws the diaphragm away from its seat in the check valve (B) and transmits the vacuum to the differential pressure regulator (C). The vacuum opens valve (C) and allows transmission of the vacuum to the feed rate adjustment valve (D).

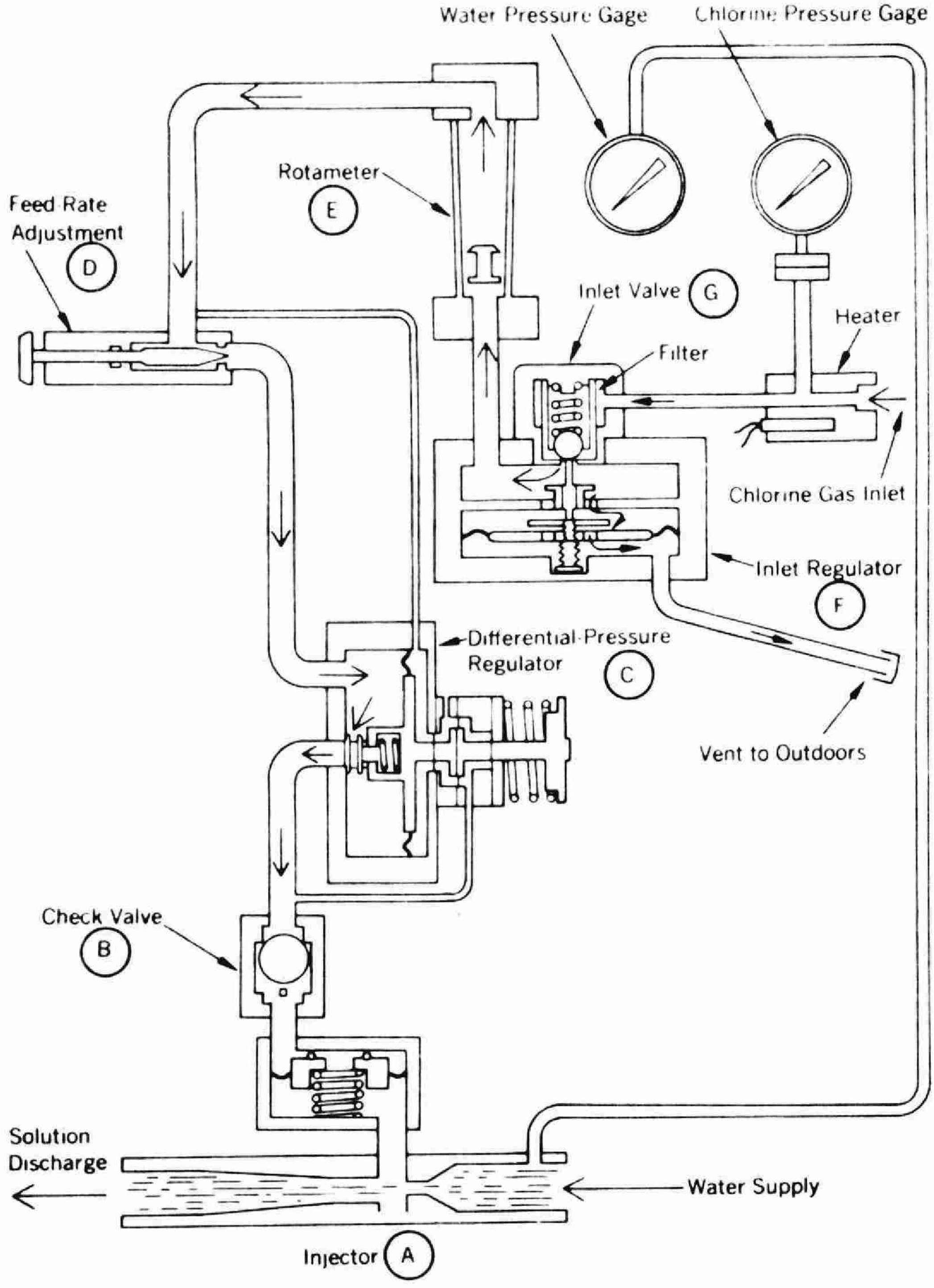


Fig. 13-4 . BIF Chlorine Feeder

Vacuum is then transmitted to the rotameter (E) and to the inlet regulator (F) to open the inlet valve (G) and allow the gas to flow back to point (A) for discharge into the system.

Failure of the injector vacuum allows the inlet valve (G) to close and stop the flow of chlorine through the system. However, should valve (G) fail to close, the resulting pressure would force the diaphragm in the inlet regulator (F) away from its seat, allowing the gas to escape through the vent to outdoors.

5. Fischer & Porter Gas Dispenser (see Fig. 13-5)

General Description

The Series 70-3400 gas dispenser safety stack regulator consists of the vacuum regulator, the differential pressure regulator, and the components that comprise the safety features, all housed in a single regulator stack. Whether the safety stack regulator has a fixed range or an adjustable range, the operation of these parts is identical.

The vacuum regulator admits gas from the pressurized gas supply and reduces the pressure of the gas from supply pressure to a constant vacuum. The differential pressure regulator maintains a constant pressure drop across the orifice of the rate valve to keep the flow of the gas

constant. In the fixed range regulator the pressure drop is factory set and fixed; the adjustable range regulator provides for the manual adjustment of the pressure drop to allow the control range of the rate valve to be varied. The safety features are incorporated to prevent damage to equipment and danger to operating personnel in the event of abnormal conditions within the gas dispenser or associated equipment. The vacuum regulator, the differential pressure regulator, and the safety features are described in detail in the following sections.

Functional Description of the Regulators

Refer to Figure 13-5 to supplement the following functional description. The description assumes that the rate valve (the manual rate valve or the flowrator valve, whichever is present) is partially open, that the gas supply containers have been connected and the gas supply valves are open, and that the ejector water supply valve has just been opened.

As the water, under pressure, is forced through the ejector nozzle, a vacuum is created within the throat of the ejector due to the high velocity of the water as it leaves the nozzle. This vacuum builds up in the gas line between the ejector and the safety stack regulator and in the chamber designated "F" in Figure 13-5. The vacuum in chamber "F" pulls diaphragm "D" down against its stops,

opening port "G". At the same time, spring "F" is compressed against the ball to seal port "F", the atmospheric relief valve. The vacuum builds up in chamber "G" and back through the rate valve, the flowmeter, the orifice block, if present, and chamber "A". Chamber "A", diaphragm "A", port "A", and spring "A" make up the vacuum regulator.

The vacuum in chamber "A" pulls diaphragm "A" downward, moving the plug of the vacuum regulator valve off its seat. Diaphragm "A" is free to move since chamber "B" above the diaphragm is open to the atmosphere through the vent line. When port "A" of the vacuum regulator valve is opened, gas flows from the gas supply containers (through the gas inlet connection block) and enters chamber "A". As the gas passes through the regulator valve, it is expanded in volume and its pressure is reduced from the pressure of the supply containers to a vacuum level.

The vacuum level in chamber "A" is unaffected by the pressure level of the supply containers and is maintained constant by the throttling action of the vacuum regulator valve as controlled by the position of diaphragm "A". The downward pull of the vacuum on diaphragm "A" is constantly opposed by spring "A" which exerts a virtually constant force in the upward direction. The diaphragm is in equilibrium (and the correct throttling action is provided) when the vacuum in chamber "A" exactly balances the force of spring "A".

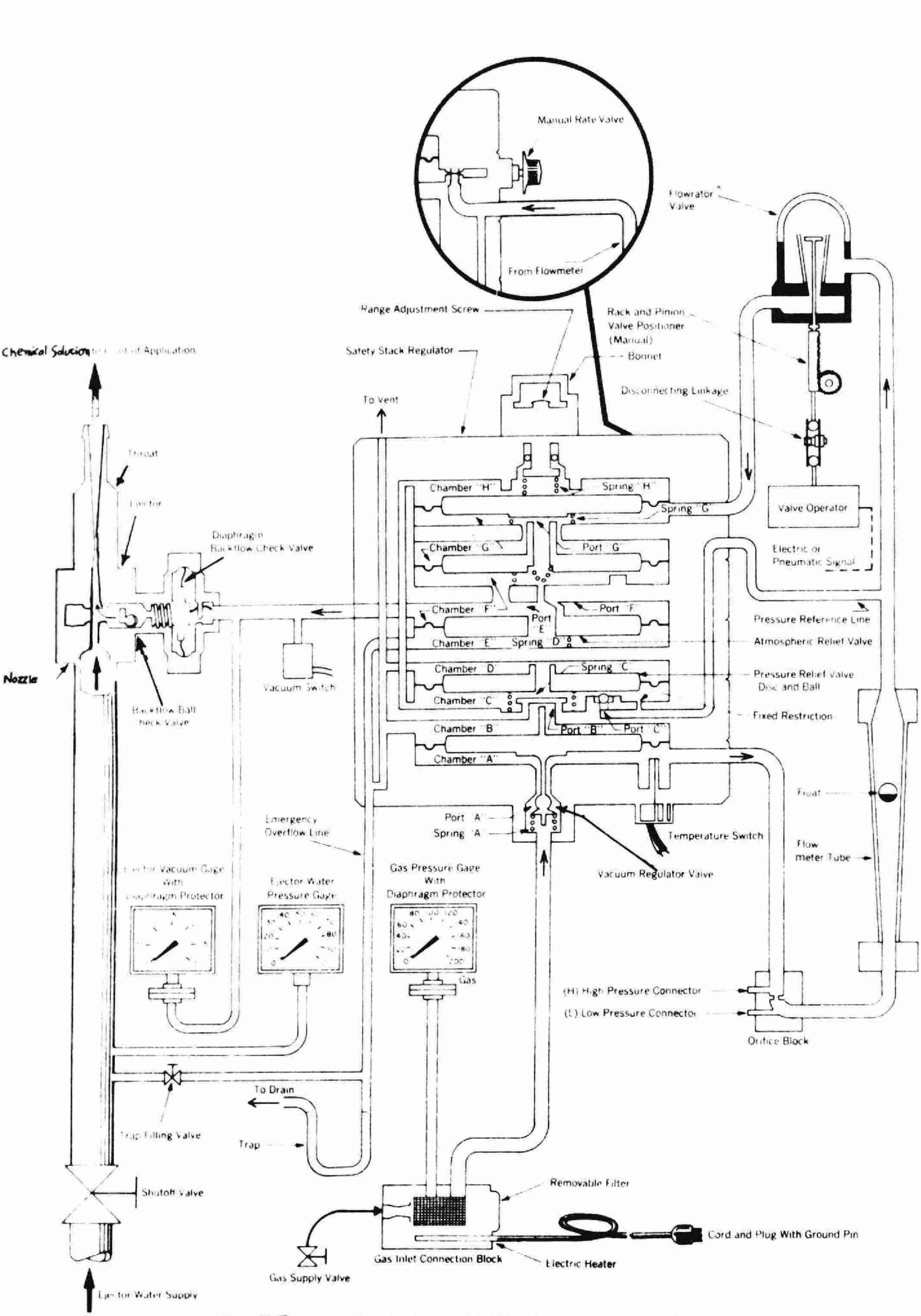


Fig 13-5 Fisher Porter Series 70-3400 Gas Dispenser With Fixed and Adjustable Range Safety-Stack Regulator

(COURTESY "FISCHER & PORTER")

The gas is drawn from chamber "A" through the orifice block, if present, through the flowmeter where the flow rate is measured and indicated, and through the orifice of the rate valve which provides for manual or automatic control of gas flow rate. The gas flows into chamber "G", through port "G" to chamber "F", and finally through the back-flow check valves into the ejector. In the throat of the ejector the gas is thoroughly mixed with the ejector water to form a chemical solution which is then transported to the point of application.

Immediately upstream of the rate valve, a separate "pressure reference line" is branched off from the main gas flow. This static line transmits the vacuum existing upstream of the rate valve through the fixed restriction and chamber "C" to chamber "H" above diaphragm "E". Chamber "G" is connected to the opposite side of the rate valve so that the vacuum downstream of the valve exists on the underside of diaphragm "E". Spring "G" exerts an unbalancing force on this diaphragm (virtually constant for the small displacements of the diaphragm) that tends to open port "G". This causes more gas to flow through the port and, therefore, through the rate valve. This increases the pressure drop across the orifice of the rate valve; the increased differential also exists across diaphragm "E" and pulls the diaphragm downward, tending to close port "G" and throttle the flow of gas.

When precisely enough gas flows through port "G" so that the spring tension is exactly opposed by the differential acting on diaphragm "E", the diaphragm is restored to equilibrium. Thus, chamber "H", diaphragm "E", chamber "G", spring "G", and port "G" make up the differential pressure regulator that maintains a constant pressure drop across the orifice of the rate valve. This keeps the flow of gas through the rate valve (and, therefore, through the gas dispenser) constant for each valve setting and compensates for any variations that may occur in the vacuum level at the ejector.

As shown in Figure 13-5, the adjustable range safety stack regulator includes an additional spring ("H") and a range adjustment screw. The tension of spring "H", which can be manually adjusted with the range adjustment screw, partially cancels the tension of spring "G". In effect, this allows the tension of the differential pressure regulator spring ("G") to be adjusted so that the pressure differential across the rate valve can be varied. Therefore, the flow rate through the valve can be adjusted (without changing the valve setting) until the gas is flowing at 100% of dispenser capacity when the rate valve is fully open.

SUBJECT:

CHLORINATION EQUIPMENT

TOPIC: 14

SHUT-DOWN

OBJECTIVES:

Trainee will be able to:

1. Demonstrate shut-down of chlorination system;

2. Perform the following steps in proper sequence:

   (a) start vent fan

   (b) shut off cylinder(s)

   (c) check chlorine pressure

   (d) shut chlorine line valves

   (e) shut water valves

SHUT-DOWN DETAILS

(1) Push button to start exhaust fan:

(a) check louvers (especially in winter) to make sure they are open.

(b) if there is ductwork for externally-mounted fan, check for air flow by placing hand on end of duct for suction.

(c) if there is no suction: (i) check to see if FAN is running; (ii) check ductwork for blockage.

NOTE: *Exhaust system (fan and motor) MUST be in operation at all times during shut-down.*

(2) Shut OFF chlorine at cylinder or manifold as required:

(a) check pressure gauge.

(b) make sure pressure gauge reading drops to ZERO.

(3) Beginning at cylinder(s):

(a) shut off *ALL* valves as you move towards chlorinator.

(b) do *NOT* shut off chlorinator *YET*.

(4) Allow chlorinator to continue operating for approximately *15 minutes, without chlorine entering it.*

WHY? To ensure complete purging of system.

(5) Shut off water supply (injector) valve.

(6) Shut off automatic control equipment such as electric plug positioner, variable vacuum valve, or pneumatic valves.

(7) If system is shut down *longer than 10 minutes, ALL* chlorine lines must be sealed from atmosphere.

WHY? Chlorine mixing with moisture from the air will cause corrosion of pipe.

TABLE No. 14-1

CHLORINATOR SHUT-DOWN SEQUENCE
1. Start vent fan
2. Shut off cylinder(s)
3. Check chlorine pressure
4. Shut chlorine line valves
5. Shut water valves

SUBJECT:

CHLORINATION EQUIPMENT

TOPIC: 15

MAINTENANCE

OBJECTIVES:

Trainee will be able to:

1. Recognize mechanical malfunctions of:

2. Describe immediate and/or long-term operational adjustments for:

3. Name most probable component(s) needing repair or replacement for:

4. List in order of probability, from highest to lowest, most probable causes of malfunction for:

   (a) vent fan

   (b) injector

   (c) rate controller

   (d) rotameter

   (e) pressure and vacuum gauges

   (f) evaporator

   (g) alarm system

   (h) recording instrument

5. Describe a daily, weekly and annual maintenance schedule.

MAINTENANCE

1. Vent Fan (see Fig. 11-1)

   (a) Inspect motor:

   - Check to see if shaft turns when motor is turned on.
   - If shaft does not turn, check if relay switch is on.
   - Check if fuses are burnt and replace if needed.
   - Check thermal overload (heater).
   - Bearing or fan blade may be seized; disconnect power and proceed to find and correct problem.
   - If motor still not running, have it repaired or changed.

   (b) Inspect fan blades:

   - Be sure blades are free to turn.
   - Check to see if blades are tight on shaft.
   - Stop fan and ensure blades are symmetrical AND BALANCED by turning blades. If balanced, blades will remain in any position.
   - Disconnect switch. Post warning tag.

     WHY? To prevent possible injury to operator.

(c) Inspect louvers:

- Be sure they open when required.
- BE SURE NO DEBRIS IS PILED AGAINST UNIT.

2. <u>Injector</u> (see Fig. 11-8)

(a) Disassemble injector.

(b) Check nozzle (throat) for plugging by rust, or accumulation of dirt. Remove blockage.

(c) Check tailway (discharge section) of injector for abrasion (particularly true when on wells or where some fine sand may be in suspension in water).

(d) Inspect ball check - SHOULD BE CLEAN AND FREE TO MOVE.

(e) Inspect diaphragm for breakage. If broken, replace.

(f) Visually inspect for leaks at joints.

(g) Replace gaskets where required.

(h) Tighten bolts where required.

(i) Check springs for corrosion.

3. <u>Rate Controller</u> (see Fig. 11-5)

(a) Inspect for possible linkage disconnection, or rack and pinion failure, stripped gears, broken shaft. (Operator must get in behind chlorinator to look. *Chlorinator should not be installed too close to wall.*)

(b) Operate controller by hand to see if gas flow can be regulated (increased or decreased).

(c) Check all seal gaskets and replace if necessary.

(d) Check for foreign material on stem and seat.

(e) Check automatic control by using manufacturer's procedures manual. (If chlorinator functioned satisfactorily on manual control, problem may be in the automatic control.)

4. <u>Rotameter</u> (see Fig. 15-1 and Fig. 11-3)

(a) See if there is any build-up of foreign material inside rotameter and/or on the FLOAT.

(b) Make sure that rotameter is properly seated at top and bottom.

WHY? If rotameter is off-centre, a vacuum leak may be created, leading to faulty operation.

(c) Inspect gaskets for defects (cracked or flattened). Replace if required.

5. Pressure and Vacuum Gauges

(a) Check for leaks.

(b) Open line at joint and check for plugging.

(c) Open gauge by removing glass and dial face. Check if gearing is meshing properly.

NOTE: *Do NOT disconnect gauge from its diaphragm assembly.*

(d) Check bellows for possible rupture (oil at connection to tube).

6. Evaporator (see Fig. 11-9)

(a) Check temperature:

- If it is *HIGH* (approx. 160°F), shut off power supply to heaters.
- If it is *LOW* (approx. 120°F), check to see if heater is functioning, or if it is burnt out.

(b) Check water level - *SHOULD BE WITHIN LIMITS SET BY MANUFACTURER*:

- If *LOW*, check "make-up" valve. If valve is manual, open it. If valve is automatic, it may need repair. Low level may also be caused by evaporation. Pour light film of oil over surface to prevent evaporation.

- If *HIGH*, drain water to level required and be sure "make-up" valve is closed. (Leaking make-up valve causes high level.)

(c) Check pressure:

- If pressure is *HIGH*, check high temperature control to see if it is functioning, because high pressure is caused by high temperature.

- If pressure is *LOW*, check chlorine supply which may be low. Increase chlorine supply. Change cylinder if necessary. Check to see if thermostat is turning on heaters at LOW temperature.

- Check incoming liquid pressure and be sure it is at proper level.

7. Alarm System (Chlorine Detection)

(a) Chlorinator Malfunction

Check functioning of system by:

- Turning off water to injector and waiting for alarm to sound (approx. 15 - 20 seconds); when alarm rings, turn water on again; if alarm does NOT sound, check linkage to switch, then check diaphragm.

- Turning off chlorine gas supply and waiting for alarm to sound; when alarm rings, turn chlorine supply on again; if alarm does NOT sound, check linkage to switch, or positioning of switch.

NOTE: *Alarm system should be checked at least once a week.*

(b) For atmosphere in chlorination room:

- If alarm system uses sensitive paper, use finger to block light to sensitized paper; listen for alarm to sound; remove finger blocking light.

NOTE: *Be sure sensitized paper is not too old, as it loses its sensitivity to light with time. SHELF LIFE - 4 - 6 MONTHS (IF KEPT AWAY FROM LIGHT).*

- Systems using a cell assembly can be tested by holding a beaker of Javex near the air intake. This should activate the alarm. System should slowly return to normal operation after removal of beaker.

8. Recording Instruments: Charts and Pens

(a) Charts (see Fig. 15-2)

- See if chart is bent.
- See if chart is misaligned.
- See if chart is jamming as it rotates.

(b) Pen (does not print) (see Fig. 15-3)

- Inspect ink-well to see if ink supply is gone.
- Fill well as required.
- Capillary tube may be plugged - run fine wire (4/1000 inch) through tube to remove foreign material.
- Pen not touching paper. Check arm of pen to see if it is bent.

MAINTENANCE SCHEDULE

Daily

(1) See that automatic controls start and stop properly.

(2) Check pump and piping for leaks.

Weekly

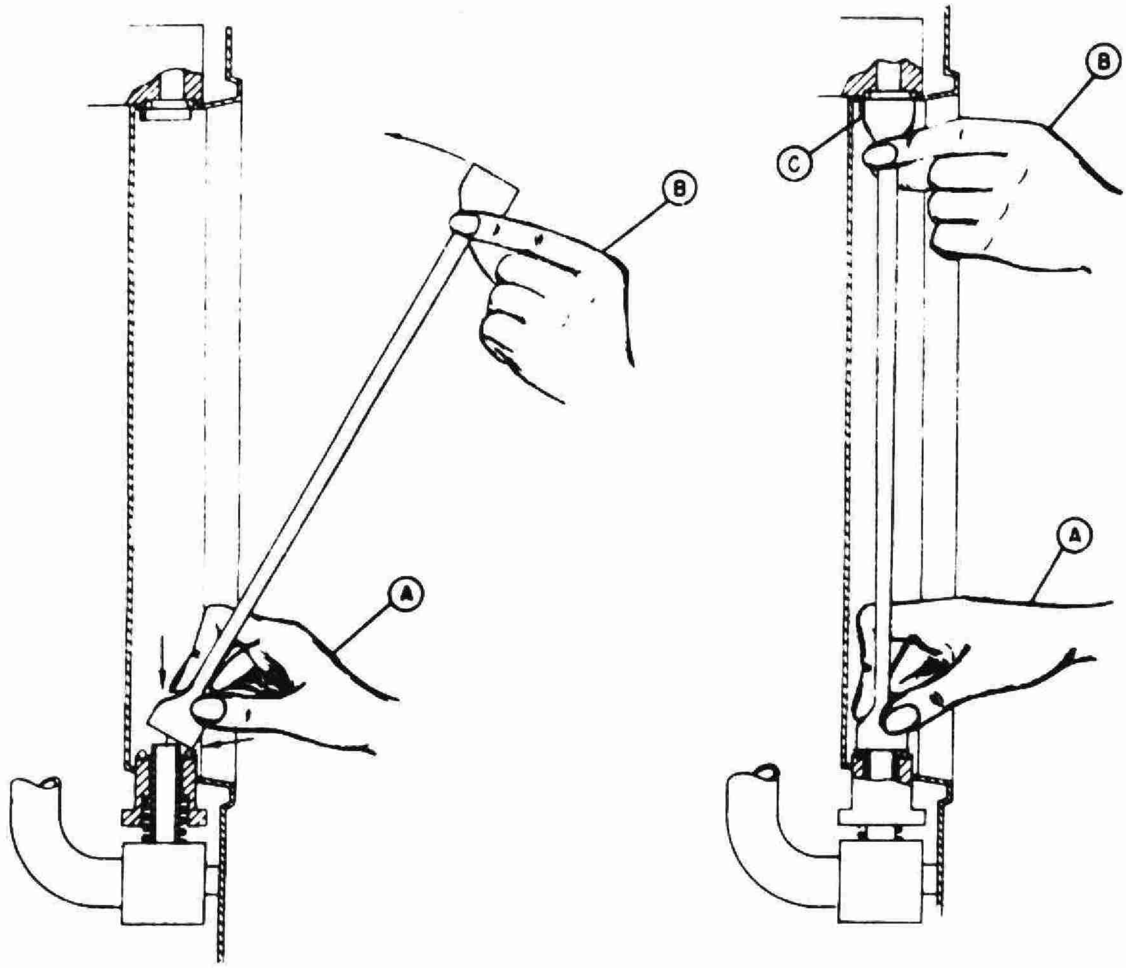
(1) Clean screens and strainers on water lines by removing from line and flushing with clean water.

(2) Operate all shut-off and rate-control valves.

Annually

(1) Remove, inspect and replace parts and packing as required.

(2) Touch up all metal parts with paint.



TO INSTALL ROTAMETER--

1. LUBRICATE BOTTOM "O" RING ONLY WITH A LIGHT FILM OF SILICONE GREASE.
2. POSITION "O" RINGS AS INDICATED. INSERT FLOAT AND STOPS IN ROTAMETER TUBE.
3. GRASP ROTAMETER BY THE TWO ENDS.
4. GUIDE LOWER END OF ROTAMETER WITH HAND "A" TO LOCATE ON "O" RING.
5. EXERT DOWNWARD FORCE WITH HAND "A" TO COMPRESS SPRING AND USE TWO FINGERS OF HAND "B" TO GUIDE TOP OF ROTAMETER INTO POSITION. ROTAMETER MUST TOUCH AT POINT "C" TO INSURE SEATING ON UPPER "O" RING.
6. RELEASE DOWNWARD FORCE ON SPRING.

TO REMOVE ROTAMETER--

1. EXERT DOWNWARD FORCE ON LOWER BELL OF ROTAMETER WITH HAND "A."
2. USE TWO FINGERS OF HAND "B" TO SWING TOP OF ROTAMETER OUTWARD.
3. LIFT ROTAMETER.

READ SCALE OPPOSITE CENTER OF BALL

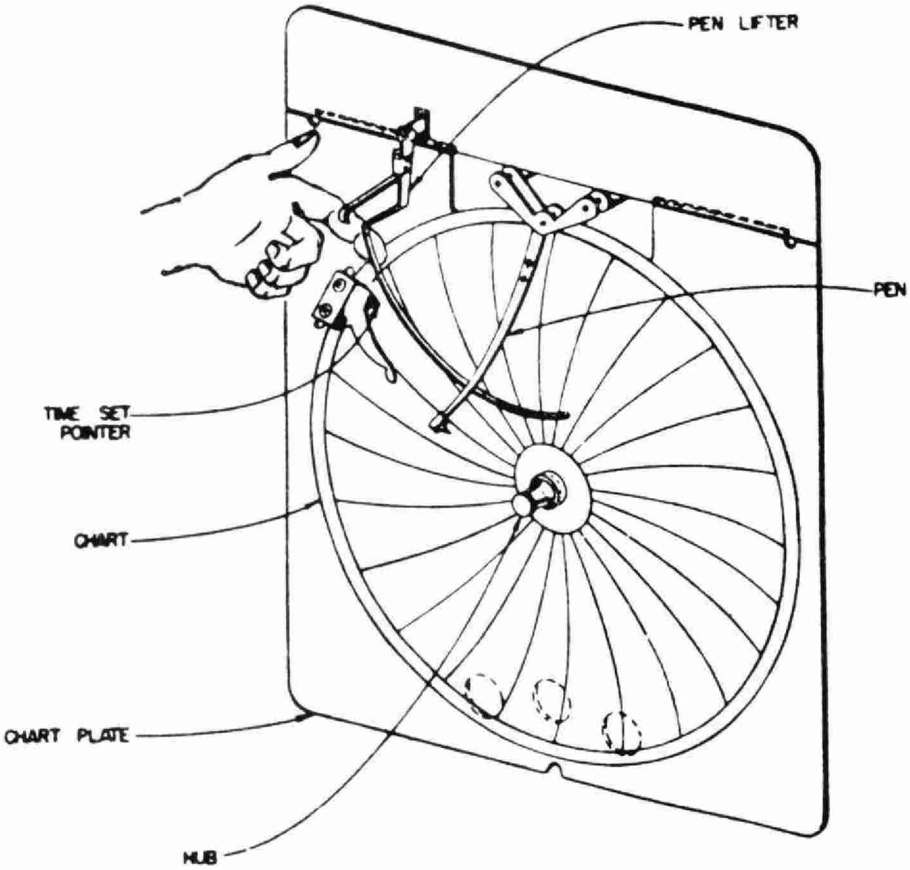
FIG: 15-1. INSTALLATION OF ROTAMETER

Used in V-Notch Chlorinators.

(1) RAISE THE PEN LIFTER.

(2) PULL OUT ON THE CHART HUB. IT WILL COLLAPSE INTO ITSELF, LEAVING THE CHART FREE TO COME OFF. REMOVE THE CHART.

(3) PUT ON A NEW CHART. PUSH IN ON THE CHART HUB SO THAT IT REENGAGES THE CHART.



(4) ROTATE THE CHART HUB UNTIL THE PROPER TIME ARC IS INDICATED BY THE TIME SET POINTER. (NOTE--- DAY AND NIGHT SECTIONS ON THE CHART) THE TIME SET POINTER AND THE PEN POINT REGISTER ON THE SAME TIME ARC.

FIG. 15-2 CHART PLATE FEATURES

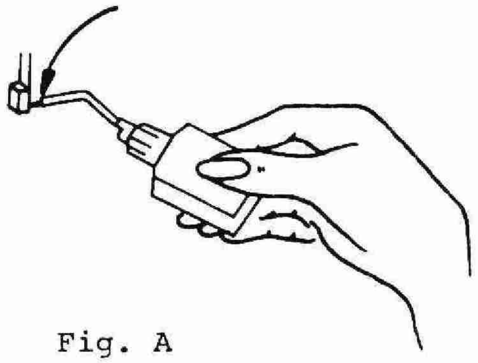


Fig. A

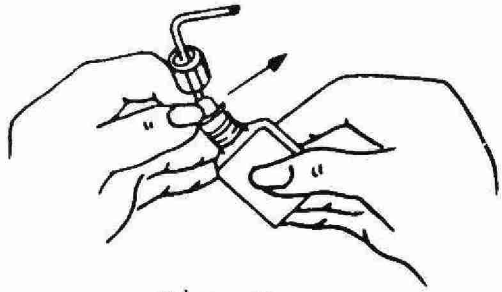


Fig. B

TO INK A BOX PEN

Fill through the tip with the plastic ink bottle as shown in Fig. 1. This method of filling insures against air bubbles or other obstruction, and also primes the pen for quick starting. Put in mo more ink than is estimated necessary. If there is doubt, a clean pen may be filled full the first time, but after that, the ink level should be kept as low as possible for cleanest lines and shortest drying time.

After using the plastic ink bottle wipe the spout and replace it tightly in the sealing hole in the bottle cap.

STARTING A STUBBORN BOX PEN

If trouble is encountered in getting a box pen to ink, proceed as follows:

1. Remove the pen from the pen-arm. To do this, hold the pen-arm firmly and turn the pen in a counterclockwise direction permitting the clip on the back of the pen to be slipped off the pen-arm. Carefully withdraw the pen from the hole in the pen-arm.
2. Fill the pen nearly full of ink.
3. Grasp the pen reservoir with the thumb on top and fore-finger beneath, and squeeze. Ink should start to ooze from the pen tip.

MAINTENANCE OF PEN

If the pen becomes dirty or begins to skip, clean it as described below. Detergent cleaners may be used, but every trace should be removed or severe feathering may result. Use only recorder ink. If long service wears a pen so that the line is too wide, replace the pen.

TO CLEAN A CLOGGED BOX PEN

1. Remove the box pen from its pen-arm. To do this, hold the pen-arm firmly and turn the pen in a counterclockwise direction This permits the clip on the back of the pen to be slipped off the pen-arm. Carefully withdraw the pen from the hole in the pen-arm.
2. Run a wire not larger than 0.005" diameter (B&S Gauge #36 or higher) or a Cleaning Wire, Part P-26488, through the tip to push out the dried ink.
3. Flush out by filling through the tip with the plastic ink bottle. Force through a surplus of ink into a tissue or paper towel to make sure the tip is clean.
4. Replace the pen.

TO REFILL THE PLASTIC INK BOTTLE

1. Pull out the spout and remove the screw cap as shown in Fig. 2.
2. Force the plug sideways, up and out. Don't try to pull it straight.
3. Fill to the line. Replace plug, cap and spout.

FIG. 15-3
INSTRUCTIONS FOR BOX PEN W E T RECORDERS

SUBJECT:

CHLORINATION EQUIPMENT

TOPIC: 16

TROUBLE-SHOOTING

OBJECTIVES:

Trainee will be able to describe and/or demonstrate trouble-shooting chlorinators with a manometer and vacuum gauge by determining the following:

(a) Chlorinator problems;

(b) What is probably wrong;

(c) What to measure;

(d) How to measure;

(e) Operating ranges;

(f) Other checks;

(g) How to correct problems.

"TROUBLE-SHOOTING" CHLORINATORS WITH A MANOMETER & VACUUM GAUGE

(1) *Measure* the vacuum over the full range of gas flow (low feed, half feed, full feed).

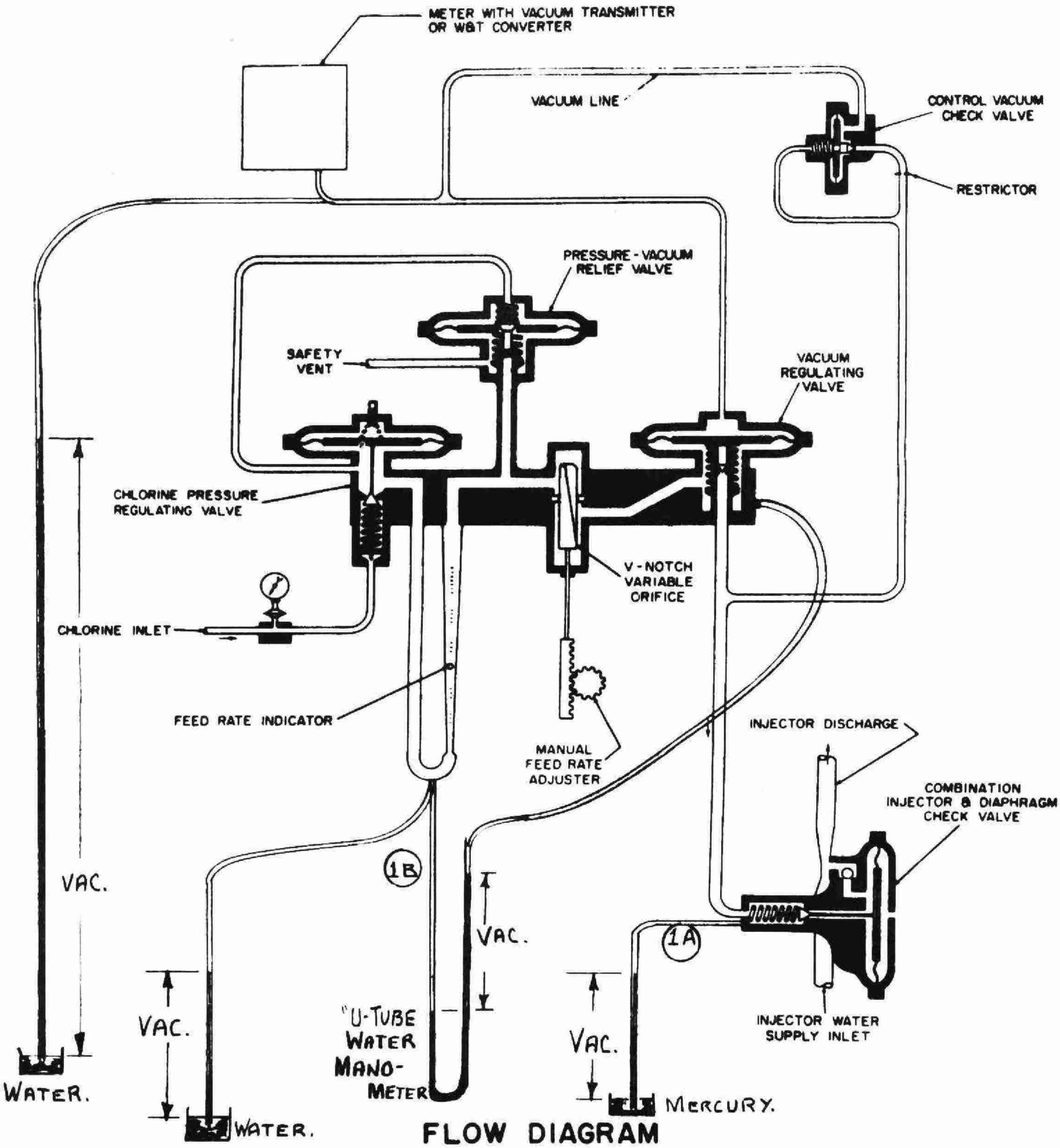
(2) *Compare* what you measure with figures given on the schematic flow diagram for the chlorinator or on signal data sheets. If the figures are right, leave that component alone and check the next element.

(3) *Make auxiliary checks* (if necessary) to pinpoint the problem.

(4) *Correct* the problem.

NOTE:

Chlorinator has plugs at most of these vacuum check points. Fittings must be supplied to make connections to manometer.



FLOW DIAGRAM

VARIABLE VACUUM CONTROL
VACUUM FROM MAIN INJECTOR
V-NOTCH CHLORINATOR - SERIES A-731

W&T

Fig. 16-1 (1A, 1B)

PROBLEM #1

Manual chlorinator will not come up to full feed. Gas pressure adequate.

What Is Probably Wrong

Insufficient injector vacuum.

What To Measure

(1A) Injector vacuum.

How To Measure

Observe gauge on machine, if it has one. If there is no built-in gauge, connect a vacuum gauge or a mercury manometer at gas inlet to injector (see Fig. 16-1, (1A)).

Operating Ranges

With gas flowing, 5" mercury minimum for manual control machines; 10" mercury minimum for variable vacuum control machines.

With gas shut off, 25" to 28 1/2" mercury static vacuum.

Other Checks

Measure operating water pressure just upstream of injector and back pressure just downstream of injector. Compare with injector data. Check piping for smooth flow immediately downstream of injector tailway. (No elbows, tees, reducers, etc.) Check for air leaks through diaphragm of diaphragm-type injector check valves.

How To Correct Problem

Clean injector throat and tailway. Clean or replace solution discharge tubing. Provide adequate operating water pressure.

NOTE:

A larger throat and tailway may only compound the problem as the greater flow creates more back pressure.

What To Measure

(1B) V-notch differential.

How To Measure

Connect a U-tube water manometer upstream and downstream of V-notch chamber (see Fig. 16-1, (1B)).

Operating Ranges

11 1/2" to 17" water.

Other Checks

Where injector vacuum is marginal or hydraulics are borderline, V-notch differential is a *more* sensitive indicator of adequate operating vacuum than the injector vacuum gauge. A "bobbing" rotameter float indicates marginal vacuum.

PROBLEM #2

Manual chlorinator feeds OK at high rates but will not control at lower rates.

What Is Probably Wrong

(2A) CPRV not throttling sufficiently. (Held open by a particle of rust, ferric chloride, etc.)

What To Measure

CPRV vacuum.

How To Measure

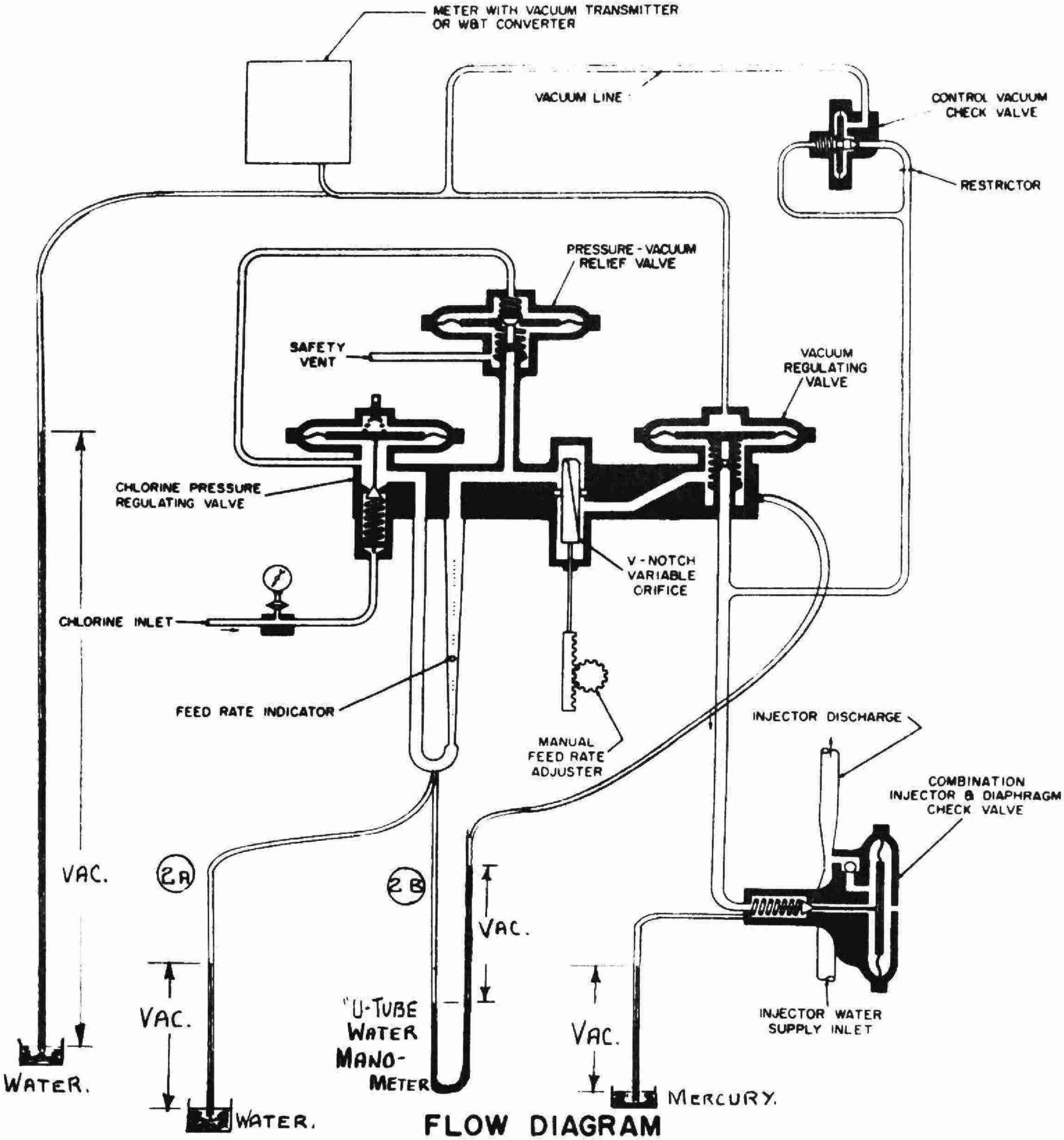
Connect a single leg water manometer at pipe plug opening in the CPRV (see Fig. 16-1, (2A)).

Operating Ranges

23" to 32" water for 400# machines.
11" to 17" water for 2000# and 8000# machines.

Other Checks

Note especially if vacuum falls at lower feeds. If it does, air or chlorine must be causing it. To find out which, turn off gas at cylinder. If rotameter float drops, it was excess gas coming in. If turning off gas does not cause float to



FLOW DIAGRAM

VARIABLE VACUUM CONTROL
VACUUM FROM MAIN INJECTOR
V-NOTCH CHLORINATOR - SERIES A-731

Fig. 16-1 (2A, 2B)

2

drop, air must be leaking in. Close off vent opening. If float drops, air was leaking through the diaphragm. If closing the vent has no effect, then air is leaking past a gasket.

How To Correct Problem

Clean CPRV cartridge. Check CPRV diaphragm for "pin-hole" leaks. Check CPRV gaskets. On "2-valve" machines, check pressure relief stem, seat and spring condition. Clean or replace parts as necessary.

What Is Probably Wrong (Problem #2 continued)

- OR -

(2B) Possibly a bad diaphragm in the differential valve is causing bypassing of the V-notch control valve.

What To Measure

Differential valve regulation.

How To Measure

Connect a U-tube manometer across differential valve (see Fig. 16-1, (2B)).

Operating Ranges

11 1/2" to 17" water difference.

Other Checks

Pressurize top of differential valve with air and check for leaks in water.

How To Correct Problem

Replace diaphragm on 2000# and 8000# units. Replace valve capsule on lower capacity machines.

PROBLEM #3

Manual chlorinator controls OK at low feeds but is erratic when full feed is attempted. Injector vacuum OK.

What Is Probably Wrong

Not enough chlorine entering to satisfy demand. Dirty CPRV or partially clogged gas line.

What To Measure

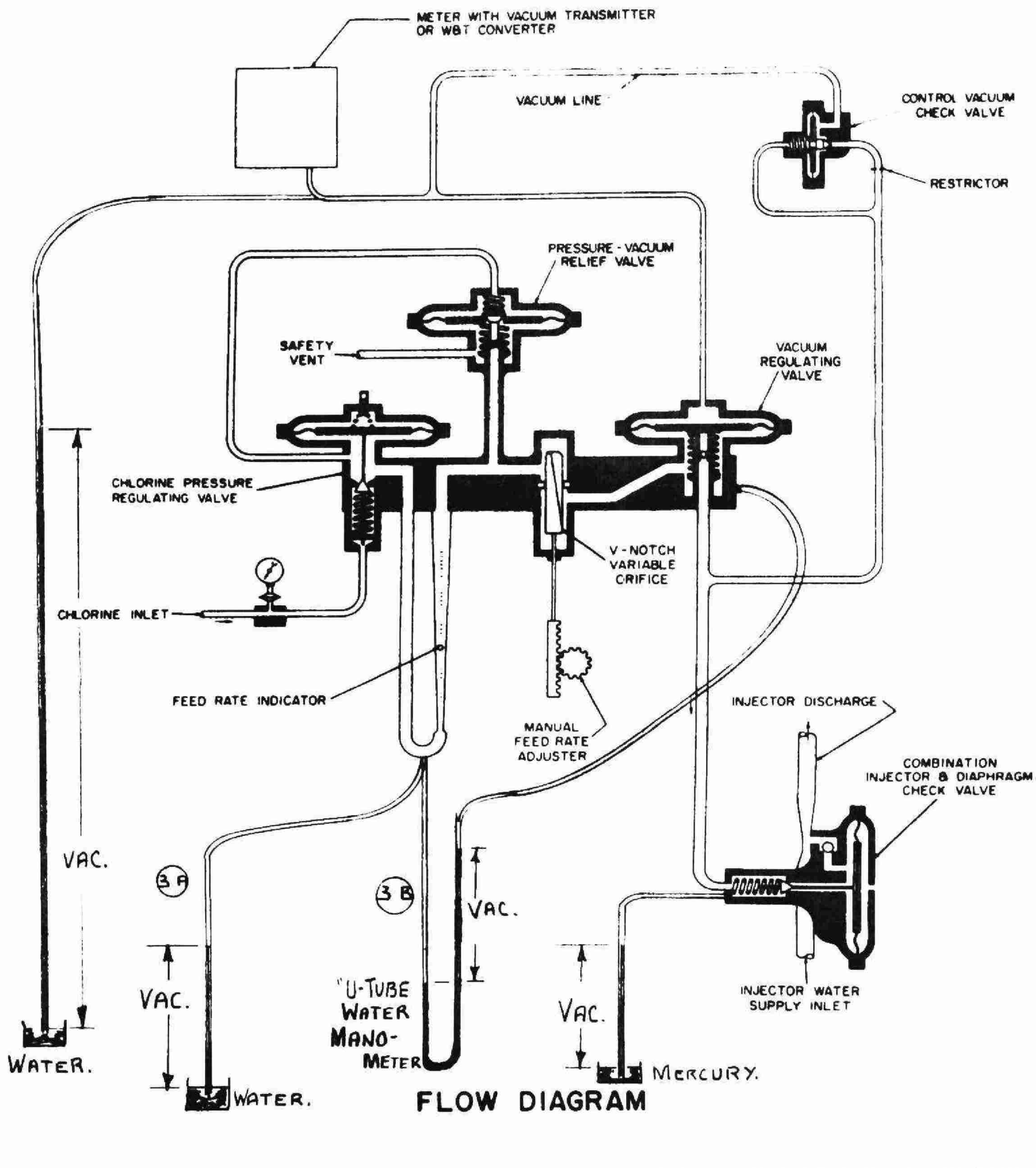
CPRV vacuum.

How To Measure

Connect a single leg water manometer at pipe plug opening in the CPRV (see Fig. 16-1, (3A).

Operating Ranges

23" to 32" water for 400# machines.
11" to 17" for 2000# and 8000# machines.
If gas line or cartridge is partially clogged, CPRV vacuum will increase to vacuum relief level. (*Caution:* start at low feed rates and gradually increase feed to prevent "blowing" manometer.)



FLOW DIAGRAM

VARIABLE VACUUM CONTROL
VACUUM FROM MAIN INJECTOR
V-NOTCH CHLORINATOR - SERIES A-731

Fig. 16-1 (3A, 3B)

Other Checks

Check gas supply pressure. See if air is entering vacuum relief port at high feed. Check vacuum relief level with a single leg manometer.

How to Correct Problem

Clean CPRV cartridge. Clean high pressure gas line. Supply adequate chlorine gas pressure (20 psig is the minimum feed performance, except on low rate apparatus).

PROBLEM #4

Chlorinator does not feed anything. Gas pressure is adequate. Injector vacuum is OK.

What Is Probably Wrong

Tube connection from upstream of V-notch to top of differential valve is disconnected or leaking.

What To Measure - - - - - - - - CPRV vacuum

How To Measure

Connect a single leg water manometer at pipe plug opening in the CPRV (see Fig. 16-1, (3B)).

Operating Ranges

23" to 32" water for 400# machines.

11" to 17" water for 2000# and 8000# machines.

Other Checks

On automatic machines make sure V-notch plug is not remaining in closed position.

How to Correct Problem

Reconnect tube line. Replace tube if cracked, kinked, or defective at ends. Tighten tube nuts.

PROBLEM #5

A variable vacuum control chlorinator, formerly working normally, now will not go below, say 30% feed. Signal levels OK.

What Is Probably Wrong

CPRV not throttling sufficiently for low feeds. (Held open by a particle of contaminant on seat or stem.)

What To Measure

CPRV vacuum.

How To Measure

Connect a single leg water manometer at pipe plug opening in CPRV (see Fig. 16-1, (4A)).

Operating Ranges

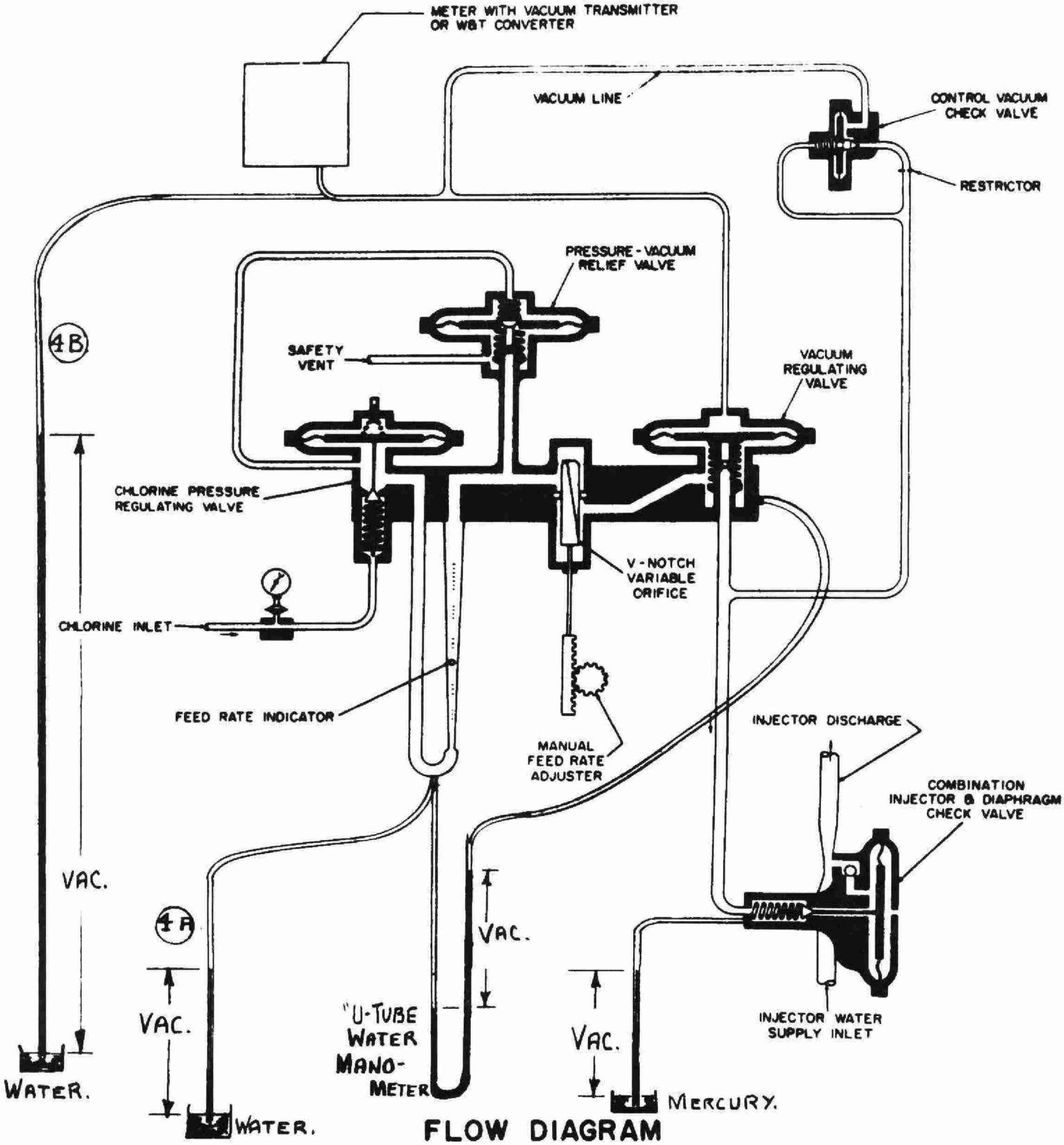
Approximately 8" of water less than for manual machines of the same type.

Other Checks

None.

How To Correct Problem

Clean CPRV cartridge. Readjust bias spring at about 20% feed after reassembly.



FLOW DIAGRAM

VARIABLE VACUUM CONTROL
VACUUM FROM MAIN INJECTOR
V-NOTCH CHLORINATOR - SERIES A-731

W&T

Fig. 16-1 (4A, 4B)

4

PROBLEM #6

A variable vacuum control chlorinator reaches full feed OK but will not go below, say, 40 to 50% feed. CPRV is OK.

What is Probably Wrong

Signal vacuum too high because of air leak bypassing restrictor through diaphragm of control vacuum check valve.

What to Measure

Signal vacuum. Remember half feed occurs at only one-quarter signal. The chlorinator feeds what the signal "tells" it to feed. If the signal vacuum does not go down, the chlorinator rate of feed will not go down.

How to Measure

Tee in a single leg water manometer at the signal connection at top rear of chlorinator cabinet (see Fig. 16-1, (4B)).

Operating Ranges

88" water for full feed.

53" for 3/4 feed.

28" water for half feed

14" for 1/4 feed.

9.6" water for 1/7th (14.3%) feed.

Note range limit of 7:1

Other Checks

Air-tight quality of control vacuum check valve diaphragm. Check gasket and stem in diaphragm. Check felt filter disc for restriction due to dirt or moisture accumulation. Check converter flapper and nozzle for freedom from dirt or restriction.

How To Correct Problem

Replace diaphragm, gasket or stem as tests indicate source of leak. Clean and dry or replace filter disc. Clean converter nozzle.

PROBLEM #7

A variable vacuum control chlorinator refuses to go full feed. Gas pressure adequate, CPRV is clean. Injector vacuum is OK.

What is Probably Wrong

(a) Signal vacuum too low because of plugged restrictor in control vacuum check valve

- OR -

(b) Air leaking into signal line.

What to Measure

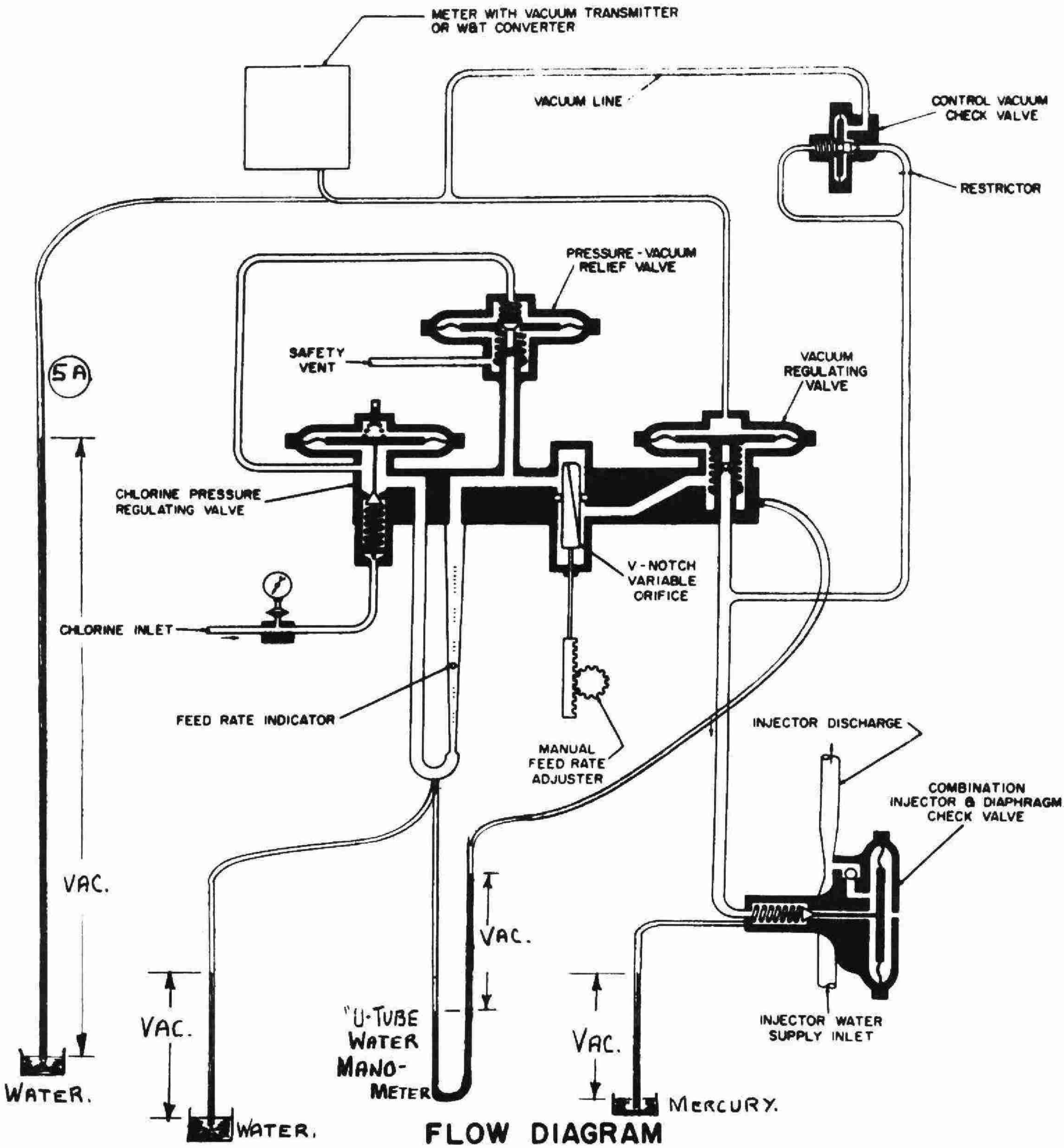
Signal vacuum.
Remember signal must be over 3 times as high to get from half feed to full feed.

How to Measure

Tee in a single leg water manometer at the signal connection at top rear of chlorinator cabinet (see Fig. 16-1(5A)).

Operating Ranges

28" water for half feed
59.2" water for 80% feed
88" water for full feed



FLOW DIAGRAM

VARIABLE VACUUM CONTROL
VACUUM FROM MAIN INJECTOR
V-NOTCH CHLORINATOR - SERIES A-731

Fig. 16-1 (5A)

Note that signal range need not be exactly 8" to 88" water. Low end trap should be in the area of 70" to 95" water. Work out numbers for your installation as explained on sheets entitled "The Arithmetic of Variable Vacuum Control" - J. Scheffer.

Other Checks

Check connecting line from signal converter to chlorinator. Pressurize with air and use soap solution or submerge in water and look for bubbles. As an alternate, trap air under pressure and observe a Tee'd in gauge. Fall of pressure indicates a leak. Check joints, fittings, tube ends, retainer nuts, etc.

How to Correct Problem

Remove and clean restrictor. Use solvent and a wire smaller than its .009 bore. Use Teflon tape on threaded joints. Correct any vacuum leaks in signal lines. System must be "dead tight" due to very limited capacity of restrictor orifice.

SUBJECT:

CHLORINATION EQUIPMENT

TOPIC: 17

CHLORINE RESIDUAL ANALYZER AND CONTROLLER

OBJECTIVES:

Trainee will be able to:

1. Describe the basic principles of the chlorine residual analyzer and controller *(optional)*;

2. Recognize the most common maintenance problems of residual analyzer recorders and recorder controllers *(optional)*.

RESIDUAL ANALYZER RECORDER

Purpose

The purpose of the residual recorder is to indicate and record the residual of chlorine in a plant discharge /or at any point within the plant.

Principle of Operation

A controlled sample of water is fed into a cell having two electrodes of different metals (bronze and platinum).

A buffer solution is added to maintain the pH within a pre-determined range.

The presence of chlorine in the water sample acts as an electrolyte between the two different metals and causes a small D.C. electrical current which is proportional to the amount of chlorine in the sample.

This is basically a *titrator* working on a continuous basis.

The small electrical current generated by the cell assembly (analyzer) is fed into an amplifier system and changed to a control voltage to activate a servo motor. The servo motor drives a gear train to position the pen on the chart and the feed-back potentiometer in the balancing circuit

until the control voltage and balancing voltage are equal. At this point, the motor stops.

An increase or decrease in the chlorine residual of the water entering the cell will cause a corresponding change in the position of the pen on the chart.

The operation of this unit must be checked daily or weekly (as experience will dictate). It can only be checked accurately with the use of an amperometric titrator (see Topic 20).

The residual recorder can be used to record either free or total chlorine residual.

For free chlorine residual recording, a pH 7 buffer solution is used, and for total chlorine residual, a pH 4 buffer plus iodine tablets are used. In some cases where reading total chlorine residual, if the pH of the water is within certain limits, a buffer solution is not required.

Chlorine Residual Alarms

Chlorine residual alarms can be activated by the use of electrical contacts adjustable to any point within the range of movement of the pen. These contacts activate a relay to pull in an alarm system, and will not handle the amperage required to operate the alarms.

RESIDUAL RECORDER CONTROLLER

Purpose

The residual recorder controller continuously indicates and records the residual of water, and raises or lowers the chlorinator setting accordingly.

Principle of Operation

This equipment is exactly the same as described under "Residual Recorder" with the addition of electrical contacts and "set point" control, plus relays, to control the increase or decrease of the chlorinator feed.

The residual recorder controller allows a "loop system" for automatic control in a plant (see Fig. 3-4).

MAINTENANCE PROBLEMS

The time involved in the transfer of water and sample through the control loop system is critical. The manufacturer's specifications must be followed very closely to set up and regulate the equipment for the best operating conditions in the treatment plant.

Maintenance

(a) Clean the cell assembly as required by the suggested maintenance program and/or as dictated by operating conditions. Use the method, materials, etc., described in the manufacturer's specifications.

(b) Regularly inspect the leads from the cell (analyzer) to the recorder unit for possible corrosion. This is particularly important for older models of equipment.

(c) Clean the electrical contacts whenever they look dirty or seem unreliable.

(d) Use a voltmeter with a low range D.C. millivolt scale to indicate whether or not:

   (i) the cell and electrode assembly is producing an electrical signal,

   (ii) the amplifier is converting this signal to the motor requirements.

Also use a voltmeter to verify if the contacts are energizing the required alarm or control circuits. The manufacturer's electrical drawings will indicate where to check this, and what voltage readings to expect.

(e) When taking gears or mechanical linkages apart, mark them with check lines to simplify reassembling into their original positions.

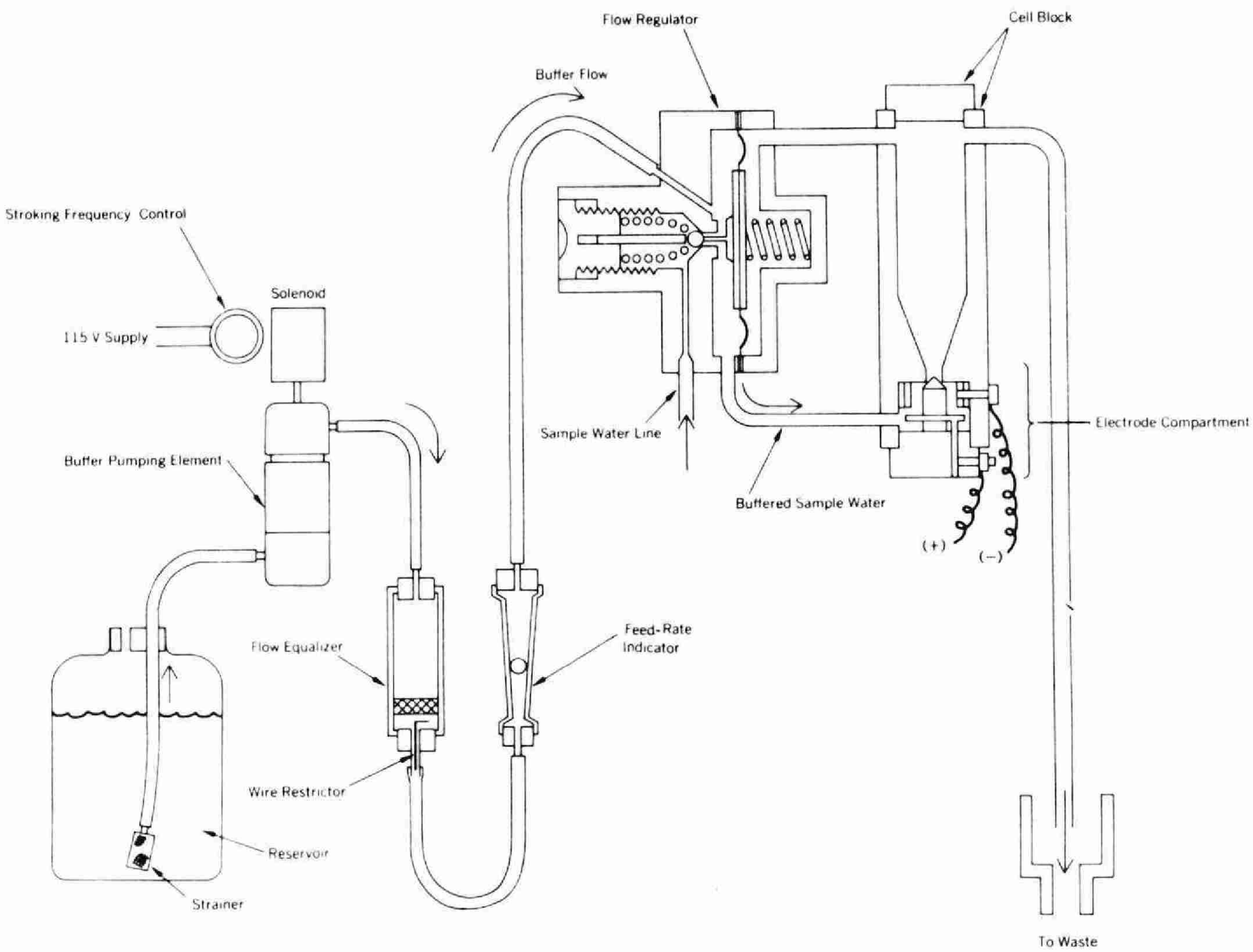


FIG 17-1. RESIDUAL CHLORINE SAMPLING CELL FOR WATER.

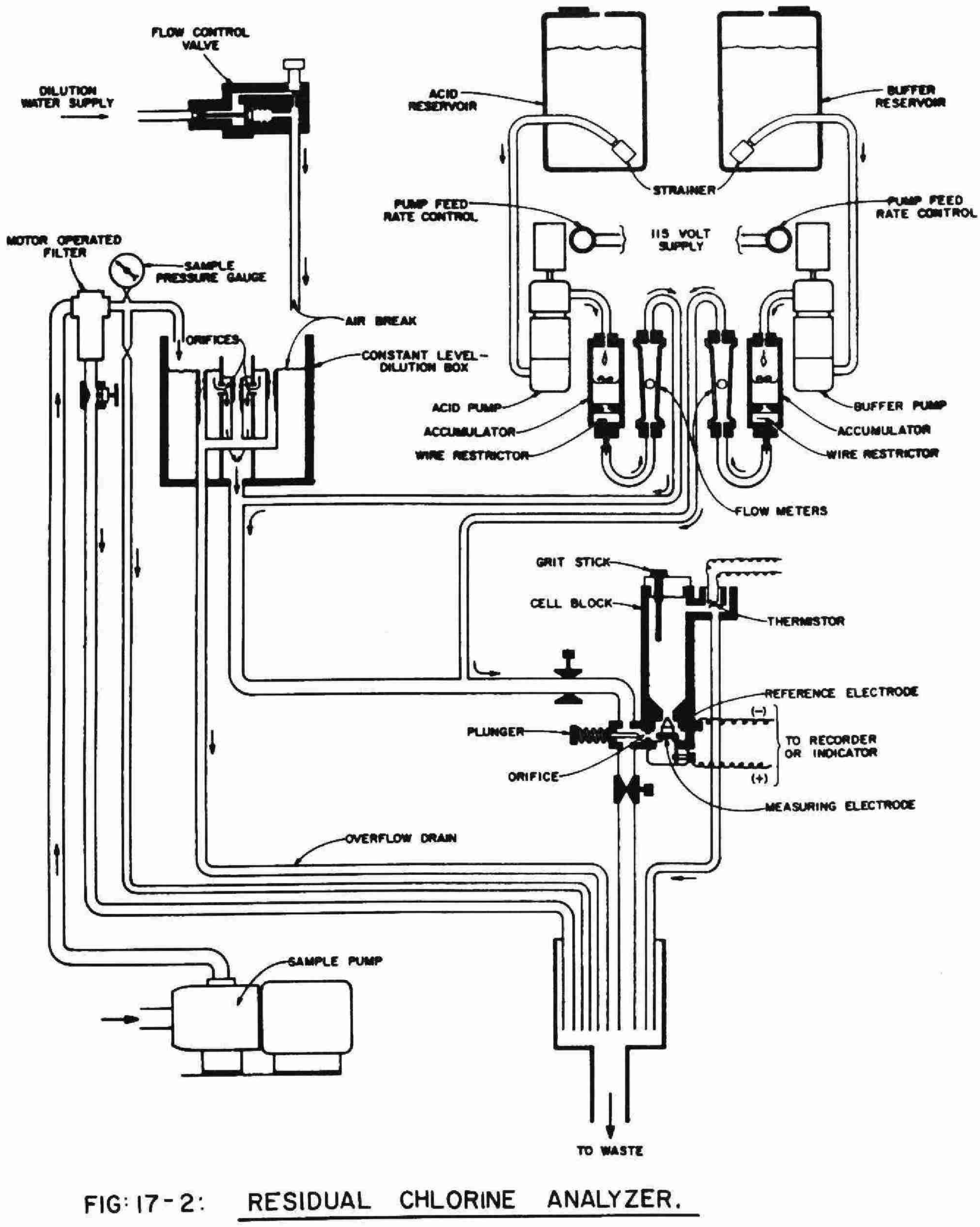


FIG: 17-2: RESIDUAL CHLORINE ANALYZER.

SUBJECT:

CHLORINATION LABORATORY

TOPIC: 18

DPD METHOD

(Diethyl Phenylene Diamine)

OBJECTIVES:

By means of the DPD method, the trainee will be able to:

1. Measure accurately (within 5%)

   (a) free chlorine residual
   (b) total chlorine residual
   (c) combined chlorine residual, i.e., b - a

   and know which tablets or reagents are to be used in each case;

2. Fully understand

   (a) the degree of sensitivity and the extent of the range of both the Nesslerizer and the Comparator (are not interchangeable)

   (b) how range and sensitivity are affected by cell depth

   (c) how he should select the instrument to be used for his plant (accuracy; range; cost; maintenance);

3. Demonstrate the DPD method when used in conjunction with each of the two instruments (Nesslerizer and Comparator) as outlined in the topic.

DPD METHOD

In a recent investigation by the Water Research Association, the DPD method was judged the best colorimetric method for chlorine and chloramines in water.

The DPD method can also be used with sea water.

PRINCIPLE OF DPD METHOD

Research studies in chlorine chemistry have resulted in the development of a very simple procedure for the determination of residual chlorine compounds in water. Free or combined chlorine residual can be analyzed by this method. Differentiation and accurate determinations of these various forms of chlorine residual simplify the control of modern chlorination processes of water treatment.

A novel feature of the Lovibond Comparator method lies in the use of compressed tablets, which are more convenient to use, and permit a procedure of exceptional simplicity.

REAGENTS REQUIRED

Comparator

DPD tablets

(a) No. 1 for free chlorine residual.

(b) Nos. 1 & 3 for total chlorine residual.

(c) Tablets Nos. 1 & 3 are combined into one tablet which is sold as No. 4. This tablet can only be used for total chlorine determination.

Nesslerizer

DPD tablets

(As greater volumes of samples are used in the Nesslerizer, tablets containing more DPD are made for it.)

THE STANDARD LOVIBOND DISCS

Comparator

3/40A disc covers the range 0.1 to 1.0 parts per million chlorine.

3/40B disc covers the range 0.2 to 4.0 parts per million chlorine.

These discs require 13.5 mm cells or test tubes. A dulling screen, which is common to both discs, must be used.

Nesslerizer

NDP covers the range 0.05 and 0.5 ppm. This disc must be used with a dulling screen and 50 ml tubes.

PROCEDURE

Comparator

1. Total Chlorine Residual

(a) Place a 13.5 mm cell or test tube (A), containing sample only, in the left-hand compartment behind the standards of the disc.

(b) Rinse a similar tube (B) with the sample, and leave only enough sample liquid in the cell *to cover* the tablet when added.

NOTE: Tablets are made by various manufacturers. Check their recommended procedures.

(c) Into tube (B) drop one No. 1 and one No. 3 tablet (or one No. 4 tablet, which is No. 1 and No. 3 combined).

(d) Allow tablets (or tablet) to dissolve until bubbling stops.

(e) Add water sample up to the 10 ml mark in tube (B), and *mix rapidly* to dissolve the remains of the tablet.

(f) Place tube (B) in the right-hand compartment of the Comparator.

(g) *After 2 minutes*, match the cells by holding the Comparator facing the north daylight and *revolve this disc until the correct standard is found. NEVER LOOK INTO THE SUN.*

(h) The figure shown in the indicator window represents parts per million *of total chlorine residual* present in the sample.

2. Differential Estimation of Free and Combined Chlorine Residual

(a) Prepare tubes as described above for total chlorine residual. Use one "blank" tube (A) and one tube (B) with just a few drops of sample.

NOTE: *If monochloramine content is high, use distilled water instead of the sample water for disintegrating the tablet.*

(b) Add one No. 1 tablet *only* to tube (B).

(c) After disintegration, add water up to 10 ml mark.

(d) Mix as before and *match at once with tube (A).* This gives *free chlorine residual.*

(e) Then add one No. 3 tablet, mix and *let stand for 2 minutes.* The colour reading represents *total chlorine residual.*

(f) Subtract free chlorine residual from total chlorine residual. Then,

Total Chlorine Residual - Free Chlorine Residual
= Combined Chlorine Residual Value.

Nesslerizer

1. Follow exactly the same procedure as described above for the Comparator, *with the following exceptions:*

(a) Use 50 ml instead of 10 ml.

(b) Use special Nesslerizer DPD tablets.

(c) There is *NO* No. 4 Nesslerizer tablet - use No. 1 and No. 3 to get an equivalent No. 4 tablet reading.

NOTE:

The readings obtained by means of the B.D.H. Lovibond Nesslerizer and disc are only accurate when Nessler tubes are used. These tubes conform to the specification used when the discs were calibrated. In other words, the 50 ml calibration mark falls at a height of 113 ± 3 mm measured internally.

FALSE COLOUR DUE TO INTERFERENCES

(1) The only possible interfering substance present in water is highly oxidized manganese. Its effect on the results can be allowed for by developing the manganese colour in a "blank" as follows:

To 10 ml of unchlorinated, filtered water sample in a separate test tube, add one DPD tablet No. 1 when only free residual is being determined, or add No. 1 and No. 3 when total residual is being determined. Mix to dissolve tablets. Using this as a blank, proceed with the test that is outlined on the following pages. In this way, the colour due to manganese has been compensated for and will not affect the test results and readings.

(2) *All glassware used must be very thoroughly rinsed after making a test, since only a trace of potassium iodide will cause chloramine colour to develop. For the same reason, transferring the tablets by hand, particularly DPD No. 1, should be avoided. Simply shake one tablet into the bottle top when adding the tablet to the Comparator cell.*

(3) The quantity of indicator used in the tablets is enough to suit the range of chlorine concentrations covered by the discs, *i.e., up to 4 parts per million.* Samples containing higher chlorine concentrations must be diluted. Concentrations of chlorine above 8 ppm will entirely bleach the colour, and give an apparently zero reading, but at this concentration the smell of chlorine would be noticeable.

Check the need for dilution by repeating the procedure using two DPD No. 1 tablets instead of one. A marked increase in colour indicates dilution is necessary. Add the required amount of distilled water first to the reagent by the measured amount of sample.

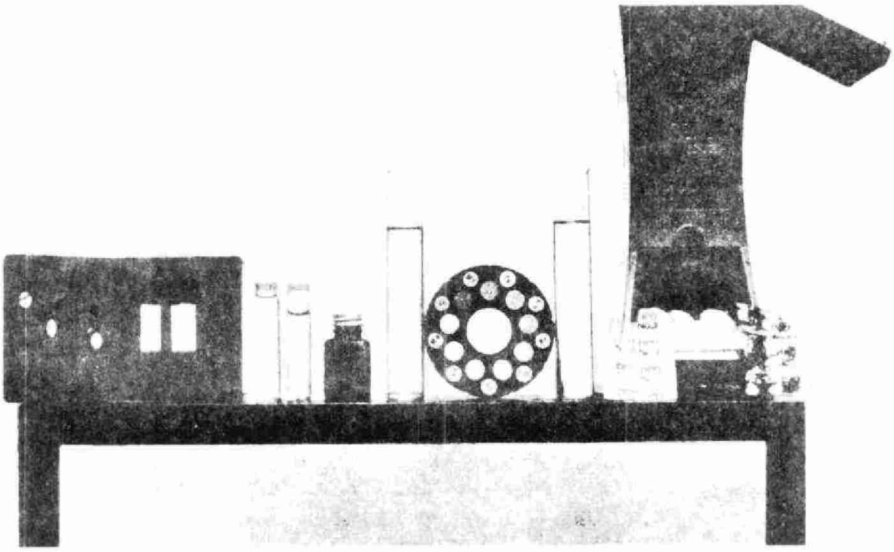


Fig.18-1
BDH Lovibond Nesslerizer
and Comparator

Fig.18-2 Using the
Lovibond Comparator

Fig.18-3 Using the
Lovibond Nesslerizer

SUBJECT:

CHLORINATION LABORATORY

TOPIC: 19

ORTHOTOLIDENE (OT) TEST

OBJECTIVES:

Trainee will be able to describe and/or demonstrate:

1. The orthotolidene method for total chlorine residual.

2. The orthotolidene flash test method for estimating free chlorine.

ORTHOTOLIDENE (OT) TEST

The orthotolidene test (OT) is used to determine the presence of chlorine residuals in the water.

The OT method is an old one dating back to 1914, and is still in use in many plants. It is reasonably good for determining total chlorine residual but the free chlorine residual result obtained by this method is only an approximate one. Nitrites, iron, and highly oxidized manganese can cause a false colour. The OT method is being replaced by the DPD and the Amperometric methods in water plants.

SAMPLING PROCEDURE

Allow 15 minutes contact time (or longer) in the chlorine chamber or filters to disinfect the water and meet its demand for chlorine. Take a sample and test for *total* chlorine residual by adding the sample to the OT reagent in a glass tube or glass container. To test for *free* chlorine residual add the OT reagent to the sample which should be at or near the freezing point. A yellow colour in the sample indicates the presence of a chlorine residual. The deeper the yellow the greater the residual. A lemon yellow colour indicates a safe residual for drinking water.

Free chlorine residual can be distinguished from combined residual under given conditions of time and

temperature. The colour caused by free chlorine residuals develops instantly at low water temperatures after the OT reagent is added to the sample. Colour caused by the combined residual develops more slowly, and reacts noticeably about 15 - 20 seconds after the addition of OT. With combined residuals, colour develops more rapidly at higher water temperatures.

It is possible that in highly alkaline waters (quite rare in Ontario) a blue tinge may result instead of the yellow colour. This may be corrected by adding some more OT reagent. Since the reagent is acidic, it will neutralize the excess alkalinity in the water sample. It should be noted that adding an excess amount of OT reagent introduces inaccuracies in the residual reading.

PROCEDURE FOR TOTAL CHLORINE RESIDUAL

1. Pour the required amount of OT reagent into the Nessler tube, colorimeter cell or other container

   Use 0.5 ml OT reagent in 10 ml cell
   0.75 ml OT reagent in 15 ml cell
   5.0 ml OT reagent in 100 ml cell
   and similar ratios for other volumes

NOTE: *OT reagent should not be kept longer than 6 months. It should be stored in amber coloured bottles, kept out of direct sunlight and should not be subjected to high or low temperature. Preferably OT reagent should be maintained at about 68°F. Fresh supplies of OT reagent may be obtained free of charge from the Ministry of the Environment laboratories.*

2. Add sample to the proper mark or volume.

3. Mix the solution

4. Temperature

   When the temperature of the sample is less than 20°C (68°F), bring it to that temperature quickly before mixing it with orthotolidene. If a Comparator cell is used, place it in hot water until the specified temperature is reached. If a Nessler tube is used, it may be handled in the same manner as the cell.

5. Colour Development and Comparison

   Colour comparison should be made at the time of maximum colour development. If the water contains predominantly free chlorine, the maximum colour appears

almost instantly and begins to fade. Samples containing combined chlorine develop their maximum colour at a rate that is largely dependent on temperature, although the nitrogenous compounds present may influence this rate. Usually at 20°C maximum colour develops in about 3 minutes; at 25°C, in about 2.5 minutes; and at 0°C, in about 6 minutes. About 5 minutes after maximum colour develops a slight fading begins. Therefore, *samples containing combined chlorine should be read within 5 minutes and should, preferably, be allowed to develop colour in the dark.*

PROCEDURE FOR FREE CHLORINE RESIDUAL

An orthotolidene *flash test* modification for free chlorine residual performed near 1°C (34°F) or freezing point minimizes the effect of chloramines and their reaction with orthotolidene to produce a yellow colour. Temperature is a critical factor. The sample should be near the freezing point to obtain meaningful results. This is in direct contrast to the OT procedure for combined chlorine residual where the temperature of the sample should be around 20°C (68°F).

The flash test requires the reading of colour within 5 seconds.

Procedure

1. Place a sample of water cooled to as close to the freezing point as possible into a Comparator cell or container. Cooling can be accomplished by placing the cell into a bath of ice cubes or freezer. The dimensions of the container must ensure immediate and complete mixture of the OT reagent with the sample.

2. Hold the container against a white background. Using a medicine dropper squirt the required amount of OT reagent to the sample of water, paying close attention to colour development. The amount of OT reagent depends on the size of the cell (refer to point 1 under Procedure for Total Chlorine Residual).

Read colour within 5 seconds.

Note: *This method is suitable for estimating only.*

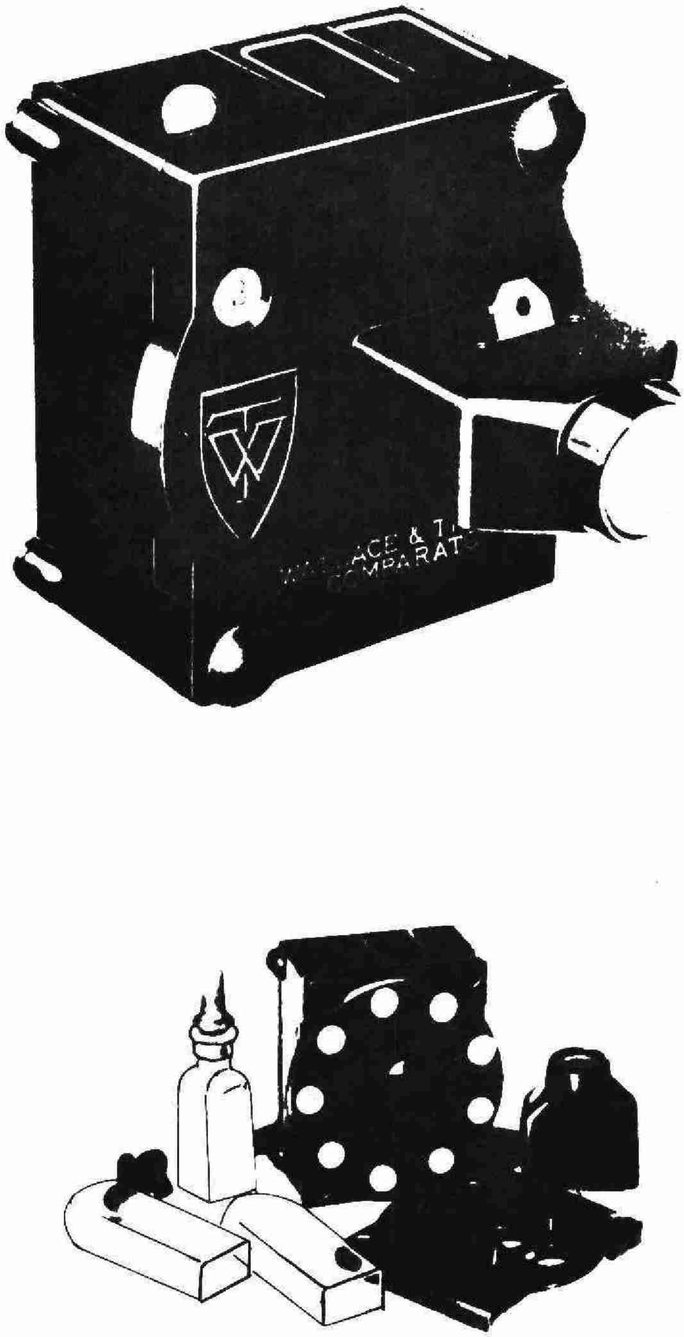


Fig. 19-1 Wallace & Tierman Comparator

SUBJECT:

CHLORINATION LABORATORY

TOPIC: 20

AMPEROMETRIC TITRATION METHOD

OBJECTIVES:

Trainee will be able to describe and/or demonstrate the following;

1. Description of instrument;
2. Titration - principle of operation;
3. Method to determine free chlorine residual;
4. Method to determine combined chlorine residual;
5. Method to determine total chlorine residual;
6. Interpretation of results;
7. Monochloramine and dichloramine differentiation.

NOTE: *TRAINEE WILL NOT BE HELD RESPONSIBLE FOR THIS TOPIC DURING THE BASIC GAS CHLORINATION WORKSHOP.*

AMPEROMETRIC TITRATION METHOD

The most accurate method of measuring free and combined chlorine residuals is by the oxidation-reduction titration procedure. This method requires the use of indicators or electrometric devices using a suitable electrode system to show when reactions are completed. Amperometric titrators (Figure 20-1) using platinum electrodes have been developed for such purposes.

Phenylarsine oxide is the reducing agent normally used as the titrating agent. It reacts with free chlorine residuals at pH 6.5 and 7.5 in a quantiative manner.

By conducting a two-stage titration with the pH adjusted at about 7 and then at about 4, free and combined chlorine residuals can be measured separately. Interference from nitrites and oxidized forms of manganese are eliminated by conducting the titrations at pH levels above 3.5

PRINCIPLE OF TITRATION

Titration determines the concentration of a substance in a solution by adding the smallest amount of a reagent (of known concentration) required to cause a neutralizing effect in reaction with a known volume of the

test solution. A graduated vessel (or pipet) is used to add the reagent to the known volume of test solution until the chemical reaction between the two is completed. The chemical reaction is observed on a microammeter.

TITRATOR: PRINCIPLE OF OPERATION

A direct current potential is impressed across two noble metal electrodes immersed in a sample cell which contains a sample of the solution to be tested. The flow of current between the electrodes is directly proportional to the quantity of halogen (such as chlorine, bromine, or iodine) in the sample. When a current is indicated by the microammeter it means that neutralization has not yet been achieved.

A *reagent* (also called a *titrant*) is added to the water, and reacts chemically with the chlorine present in the solution, thereby neutralizing a portion of the chlorine. As more titrant is added, more chlorine is "removed", causing the current flowing between the electrodes to diminish as indicated by the microammeter pointer moving down the scale. Finally, sufficient titrant is added to react with all the chlorine, and no further deflection on the meter takes place. This is called the *end point.*

The amount of chlorine originally present in the test solution is determined by noting the amount of titrant used to attain the end point, and calculated as follows:

Calculation

ppm (mg/l) of chlorine = ml of titrant used **

** The strength of the titrant has been adjusted to avoid calculation of the results. This is only the case when 200 mls of the sample is used.

PROCEDURE

Volume of Sample

For chlorine residual concentrations of 2 mg/l (ppm) or less, titrate 200 ml.

For chlorine residual concentrations above this range, use a 100 ml sample. In this case multiply the result by a factor of 2.

Use a sample so that a 2 ml phenylarsine oxide solution is required.

Filling the Pipet

NOTE: *Fill the titrant (phenylarsine oxide solution) to the engraved 0 level.*

Titration of Free Chlorine Residual

1. Fill the pipet with the titrant (phenylarsine oxide solution) to the engraved 0 level.

2. Fill the solution jar with 200 ml of sample, or 100 ml of sample, as noted under Volume of Sample.

3. Unless the pH of the sample is definitely known to lie between 6.0 and 7.5, add 1 ml pH 7 phosphate buffer solution and switch the instrument on.

4. Titrate by adding phenylarsine oxide solution and observe current changes on the microammeter. As long as addition of phenylarsine oxide produces a definite decrease in current, free chlorine is present.

5. *As the end point is approached*, the response of the microammeter to each increment becomes more sluggish, and *smaller increments of phenylarsine oxide are added.*

6. The end point is just passed when a very small increment of phenylarsine oxide no longer causes a decrease in current.

7. The pipet is then read and the last increment of titrating solution is *subtracted* from the reading to give a value representing the free chlorine residual.

Titration of Total Chlorine Residual

1. To the sample remaining from the free chlorine titration add exactly 1 ml potassium iodide solution and then 1 ml of pH 4 buffer solution *IN THAT ORDER*.

2. Titrate with phenylarsine oxide solution to an end point, just as above for the free chlorine residual. It is most convenient *NOT* to refill the pipet but simply to continue the titration after recording the figure for free chlorine residual.

3. After concluding the titration and having found the end point, *subtract* the last increment again to determine the amount of titrating solution actually used in the reaction with the chlorine. *If the titration was continued without refilling the pipet,* this figure represents the *total chlorine residual.* Subtracting the free chlorine residual from the total gives the combined chlorine residual, or:

Total Chlorine Residual - Free Chlorine Residual

= Combined Chlorine Residual

<u>*NOTE:*</u> *Wash the apparatus and sample cell thoroughly to remove iodide ion after this determination.* <u>*Why?*</u> *To avoid inaccuracies if the titrator is subsequently used for free available chlorine determination.*

4. The determination of the total chlorine residual and the free chlorine residual may be made on separate samples. If only the total chlorine residual is required, treat the sample immediately with 1 ml potassium iodide solution followed by 1 ml pH 4 buffer solution. The titration is carried out with phenylarsine oxide solution as described above.

INTERPRETATION OF RESULTS

Chlorine demand-free water is not necessary when making up the reagent solutions. The volumes of solution used are so small that the slight chlorine demand of distilled water has no significance. On the other than, the pH 7 buffer solution must be chlorinated for destruction of all ammonia contamination coming from the phosphate salts. Otherwise any ammonia traces present in phosphate salts may convert significant amounts of free chlorine in the sample to combined chlorine, when the pH 7 buffer is added before titration for free chlorine. Since the pH 4 buffer is added after that titration, traces of ammonia which might be present in this buffer will cause no similar error. Of course, the pH 7 buffer must be carefully dechlorinated after the ammonia has been destroyed.

MONOCHLORAMINE AND DICHLORAMINE DIFFERENTIATIONS

It is often desirable to differentiate between the monochloramine and dichloramine portion of the combined chlorine residual in a sample solution. This differentiation is accomplished in the following manner:

1. Perform the precedure outlined in PROCEDURE (Titration of Free Chlorine Residual). Note the reading in ppm (free chlorine).

2. Add 4 to 5 drops of potassium iodide, 5% solution, to the sample jar. If monochloramine is present, the ammeter pointer will deflect to the right.

3. Titrate to the "end point"; note the reading in ppm.

4. Add 1 dropper of pH 4 buffer solution and add 1 dropper of potassium iodide, 5% solution, to the sample jar. If dichloramine is present, the ammeter pointer will again deflect to the right.

5. Titrate to the "end point"; note the reading in ppm.

The difference between the ppm readings obtained in step 1 (free chlorine) and step 3 represents the *monochloramine* component.

The difference between the ppm readings obtained in step 3 and step 5 represents the *dichloramine* component.

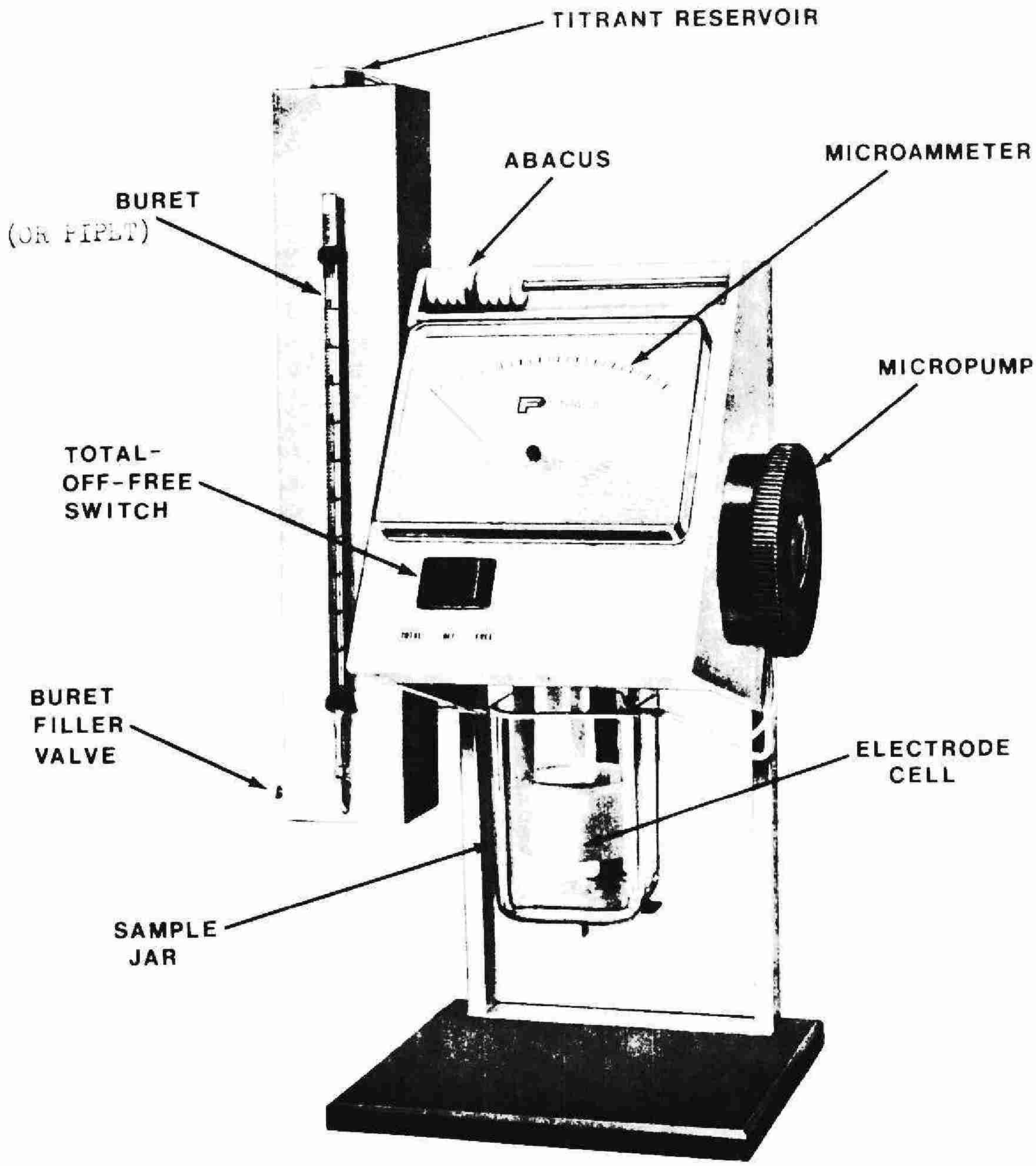


Fig. 20-1 Amperometric Titrator
(courtesy of Fischer & Porter)

APPENDIX A

O N T A R I O

MINISTRY OF THE ENVIRONMENT

SANITARY ENGINEERING BRANCH

CHLORINATION OF POTABLE WATER SUPPLIES

Technical Bulletin 65-W-4

Revised September, 1973

CHLORINATION OF POTABLE WATER SUPPLIES

I N D E X

CHLORINATION OF POTABLE WATER SUPPLIES

1.0 INTRODUCTION

1.1 Purpose of Bulletin

To provide a minimum standard of design and operation of chlorination facilities. New installations should meet the criteria as set out in the bulletin and existing facilities are to be brought up to standard in a reasonable length of time.

1.2 When Disinfection Required

Treatment by continuous and adequate disinfection is required when the supply is obtained from a surface source; when the supply is exposed to contamination during treatment; when ground water sources are or may become contaminated, as in fractured limestone areas; or where local conditions, such as flooding, indicate the need.

2.0 EQUIPMENT

2.1 Capacity

Chlorination equipment shall have a maximum feed capacity at least 50 per cent greater than the highest expected dosage required to provide a free chlorine residual. In addition each gas chlorinator not supported by additional standby units of equal capacity shall have a conversion kit sized to double the capacity of the machine.

2.2 Chlorinators and Controls

Dependable feed equipment, either of the gas feed or positive displacement solution feed type, shall be used for adding chlorine. Automatic proportioning of the chlorine dosage to the rate of flow of the water treated shall be provided at large plants and at all plants where the rate of flow varies without manual adjustment, or operation, of valves and/or switches.

2.3 Duplicate Equipment

Chlorine feed equipment at plants providing chlorination to ensure the safety of the supply shall be installed in duplicate, to provide uninterrupted operation of equipment during times of breakdown. In addition, spare parts consisting of at least the commonly expendable parts such as glassware, rubber fittings, hose clamps, and gaskets, should be provided for effecting emergency repairs.

For a multi-well supply system requiring chlorination for disinfection, the standby requirement may be met by one portable unit.

2.4 Weigh Scale

When gas feed chlorinators are employed, a set of corrosion resistant scales should be made available for weighing the chlorine cylinders serving each operating chlorinator.

2.5 Hypochlorite Solution

Where a powdered product is used, hypochlorite solutions shall be prepared in a separate tank. The solution is allowed to clarify before it is directed to the solution storage tank serving the hypochlorinator.

2.6 Safety Equipment (Gas application only)

Each plant shall have readily available, a self-contained or air-supplied type of respiratory protective equipment. Smaller installations may make arrangements with a local fire department or other agency for the loan of the required equipment on an emergency basis with a canister type mask being located at the plant.

When a canister type mask is used in place of a self-contained or air-supplied unit the operators must be made fully aware of its limitations and the location of the more adequate equipment.

One respirator shall be immediately available, located in a conspicuous location outside the area of probable contamination.

Protective clothing including gloves, goggles and safety shoes shall be available for persons handling chlorine.

Eye wash fountains shall be available in case of accident.

Preferably weigh scales for 150 pound cylinders shall be recessed in the floor

Safety chains shall be used to retain 150 pound cylinders, either in storage or on weigh scales, in a safe upright position.

2.7 Building Detail (Gas application only)

Gas chlorine equipment - chlorinators, weigh scales, chlorine cylinders - must be located in an isolated building, room or rooms. In larger installations the storage and scale facilities should be in a room separated from the chlorinators. The construction of the room or rooms should be of fire resistant material and have concrete floors.

Ton cylinders shall be stored on their sides on level racks, between four and eight inches off the grade. Chlorine should not be stored below ground level and the cylinders must be protected from excessive heat, dampness, and mechanical damage.

Areas containing chlorine or chlorinator equipment shall be clearly marked "DANGER! CHLORINE STORAGE" or "DANGER! CHLORINE FEED EQUIPMENT" as applicable.

The exit doors shall be hinged to open outwardly. There shall be two or more exits if the distance of travel to the nearest exit exceeds 15 feet. In each case, one door should be on an outside wall.

Continuous mechanical ventilation at the rate of three air changes per hour shall be provided, or screened openings to the outdoors shall be provided within six inches of the floor in the ratio of one square foot per 500 square feet of floor area. Similar openings shall be provided in or near the ceiling. The openings shall be distributed to produce the maximum air circulation across the floor. Secondly, provision for emergency mechanical ventilation should be made sufficient to produce 30 air changes an hour taking suction at a maximum of three feet above floor level.

Th temperature in the storage and scale room shall not be higher, and preferably slightly lower, than that in the chlorinator room. The gas lines between the scales, chlorinators and injectors shall not be located on an outside wall or in a location where low temperatures may be encountered.

2.8 Testing Equipment

All installations must be equipped with a permanent standard chlorine residual comparator test kit. When free residual chlorination is mandatory an amperometric titrator is also required.

In larger installations, or where poor raw water quality and/or minimum supervision indicates a hazard, an automatic residual analyzer and recorder is required. The chlorine residual recorder shall be equipped with a low residual alarm and installed to measure the chlorine residual in the water leaving the plant.

3.0 ROUTINE OPERATION

3.1 Chlorine Residual

For complete water treatment plants which effect both pre- and post-chlorination, or when a minimum of two hours contact time is assured before distribution after the application of chlorine, or for ground or protected surface water supplies, proven to be materially free from bacterial and viral contamination, the minimum chlorine residual shall be 0.2 mg/l. For all other water supplies the minimum chlorine residual shall be 0.5 mg/l.

The chlorine residual test is performed on a sample of the plant or pipe line-effluent, after it has been held for 15 minutes.

When ground water sources are proven to be free from possible viral and/or bacterial contamination they may be exempted from chlorination.

As circumstances demand the minimum requirements for chlorine residual may be increased.

A free residual chlorination program may be made mandatory, depending on the source of supply and treatment works, and it is a preferred method of treatment.

It is suggested that a chlorine residual be maintained in all active parts of the distribution system.

The selection of appropriate disinfection procedures are contingent upon the results of bacteriological and other evaluations on the total water system including the source of supply.

3.2 Chlorine Application Points

Where possible pre- and post-chlorination shall be practised. When only post-chlorination is possible free residual chlorination should be considered, and a minimum contact time of 15 minutes, before the first possible consumer, shall be provided at all times.

3.3 Chlorine Residual Test

The following procedure shall be followed in performing the orthotolidine chlorine residual test.

1. Draw sample of chlorinated water. The tap should be kept running continuously or for a few minutes before taking the sample.

2. Allow sample to stand for 15 minutes to simulate the required minimum contact period.

3. Use 0.5 ml of orthotolidine (O.T.) reagent in 10 ml cells, 0.75 in 15 ml cells, and five ml in 100 ml tubes. Place reagent in testing tube; add sample to required volume; and mix. When the temperature of the sample is less than 68^{o}F bring it to that temperature quickly after mixing with the O.T.

4. A colour comparison is made when the maximum colour develops.

5. The test results are recorded in the plant records and any necessary alteration is made to the chlorine application rate.

The above procedure is satisfactory for determining the total available chlorine residual. When the free residual is required the sample must be near 32^{o}F when the O.T. is added and the colour comparison is made immediately. The orthotolidine-arsenite (O.T.A.) test can also be used to determine the free available chlorine residual.

The accuracy of an automatic chlorine residual analyser shall be checked daily. This is accomplished using either the amperometric titration or orthotolidine colourimetric test procedures. The results of the check are inscribed on the recording chart along with the date and operator's initials, opposite a mark showing the time of the check.

The chlorine residual test must be performed frequently enough to ensure that an adequate chlorine residual is maintained at all times. Such points as raw water quality and a resultant variation in chlorine demand, and changing flow rates must be taken into consideration. When a residual analyser alarm system is used the testing frequency may be reduced.

3.4 Records

Minimum records shall include:

1. daily records of the chlorine used and scale readings,
2. results from all chlorine residual tests,
3. the flow rate and chlorine feed rate at the time of testing,
4. water used and chlorine dosage in mg/l on a daily basis,
5. detail on chlorine cylinder changes, orders and chlorine on hand, and
6. monthly and yearly summaries of chlorine consumption and feed rates.

4.0 EMERGENCY OPERATION

Where chlorination is required for disinfection purposes a continuous feed of chlorine must be assured. For this type of service the operating authority shall develop a standby operating procedure to cover emergencies. The procedures developed shall be posted in a prominent location in the plant and all operators shall be made aware of the information thus given.

The emergency information shall include:

1. the order not to pump unchlorinated or inadequately chlorinated water to the distribution system,

2. the name, address and telephone number of -
   (a) senior supervisory personnel,
   (b) medical officer of health,
   (c) Ontario Ministry of the Environment,
   (d) chlorinator service company, and
   (e) chlorine supplier,

3. the order to notify the Ministry of the Environment, and the medical officer of health immediately if unchlorinated or inadequately chlorinated water is directed to the distribution system,

4. details on emergency chlorination procedures,

5. a statement on operator responsibility, and

6. details on announcing a "Boil Water Order" (developed with MOH).

When emergency chlorination is provided the chlorine residual in the water leaving the plant shall be 1.5 mg/l.

When unchlorinated or inadequately chlorinated water has been directed to the distribution system, and until direction is obtained from the Ontario Ministry of the Environment, the chlorine feed rate shall be increased and a program of hydrant flushing initiated to provide a chlorine residual of 1.0+ mg/l in the whole of the distribution system. When increasing the chlorine residual or carrying out an extensive hydrant flushing program, notify all customers who may be adversely affected.

5.0 ADVERSE BACTERIOLOGICAL RESULTS

When the results from bacteriological samples collected from the distribution system do not meet the requirements of the Ontario Ministry of the Environment Drinking Water Objectives, the Ontario Ministry of the Environment and the local medical officer of health shall be notified. The Ministry will recommend corrective action suited to the individual circumstances. The recommendation may include one or a number of the following procedures:

(a) the disinfection, for a 24-hour period, of the distribution system with a solution having a starting strength of 50 mg/l of available chlorine;

(b) the initiation of chlorination procedures on an unchlorinated supply;

(c) an increased chlorine residual requirement together with a distribution system flushing and/or swabbing program;

(d) the collection of further samples;

(e) a recommendation to the medical officer of health that a "Boil Water Order" be issued.

6.0 DISINFECTION OF NEW WORKS

6.1 Preparation

Before disinfection is attempted, all surfaces must be thoroughly cleaned. Pipe lines are flushed with potable water until a "turbidity-free" water is obtained at all ends. Where possible foam swabs should be used to assist cleaning. Reservoirs are to be brushed as required, to obtain clean surfaces, and disinfected as per AWWA Standard D 102-64 or equivalent.

As chlorine is a surface active disinfectant it may not penetrate crevices or particles of debris. Therefore, a thorough cleaning is necessary if the disinfection program is to be effective.

6.2 Disinfection

Disinfection may be accomplished by one of the following procedures.

1. In mains all surfaces shall be in contact, for a period of 24 hours, with a chlorine solution having a starting strength of 50 mg/l. If a residual of less than 25 mg/l remains at the end of the contact period the procedure shall be repeated.

2. In large mains a "slug method" may be used, whereby a slug of water containing at least 300 mg/l of available chlorine is moved through the pipe at a rate such that the chlorine is in contact with the pipe for at least 3 hours.

3. To conserve water and chemical, reservoirs may be disinfected by spraying all surfaces with a chlorine solution havin a starting strength of 250 mg/l available chlorine. Special protective clothing and self-contained or air-supplied type respirator must be used by personnel performing the spray procedure and necessary safety precautions adheared to.

4. When surface conditions are not ideal, such as will be encountered in used works, special disinfection procedures will be required. This could include the maintenance of a chlorine residual for an extended period of time.

6.3 Testing

After disinfection, and when the chlorine residual in the treated works is at or below the normal operating level, bacteriological samples shall be collected. When a 0.2 mg/l or greater available chlorine residual is to be maintained in or after the new works, one set of satisfactory bacteriological results shall be obtained before the system is placed into operation. Otherwise, a minimum of two sets of coliform-free results shall be obtained before the works are placed in service.

APPENDIX B

SAFETY - LABORATORY

YOU NEED:

Protective clothing

Marked container for broken glass

First aid kit

SAFETY HINTS

Do not use laboratory glassware for food.

Practice good housekeeping. Keep all unnecessary equipment out of working areas.

Keep areas around sinks and taps clear. You never know when you will have to wash chemicals off your hands quickly.

Wipe up all spills *immediately.*

Label all reagent bottles *clearly* so they can be identified. The date when the reagent was made up, or received, should be on the label since some chemicals, especially nitrogen compounds, become unstable with age.

When diluting, always add concentrated acids or bases *slowly* to the water, allowing time to cool. Use only heat resistant (Pyrex) glassware. When diluting sulphuric acid, or when making up a solution of sodium hydroxide, *cool the solution in a water bath.*

CAUTION: Chromic acid cleaning solution is a mixture of sodium or potassium dichromate in concentrated sulphuric acid. It dehydrates and oxidizes most organic matter, including clothing. Treat it with care!

Use water as a lubricant when making glass-to-hose connections. For vinyl tubing, hot water can be used to make the plastic more pliable. *Wear gloves* when making hose connections to glass tubing.

Suction bulbs should be used on all pipettes. A valved type sold as a "PROPIPET" will save fumbling.

USE CAUTION when combining chemicals found in your laboratory. Some combinations produce unexpected and unpleasant reactions.

When disposing of any chemical in the sink, *dilute* with plenty of water.

Store all bottles of hazardous liquids near floor level in ventilated cupboards.

LAB. SAFETY - (CONTINUED)

Study and learn the right sections of the antidote chart. You must know first aid for dealing with lab accidents.

HASTE MAKES WASTE (and accidents). Planning saves more time than hurrying *and produces fewer mistakes.*

APPENDIX C

PERSONAL HYGIENE

For the sake of your health and the health of your family, follow this list of do's and don'ts.

1. Never eat your lunch or put anything into your mouth without first washing your hands.

2. Do not smoke while working in tanks, on pumps, trucks, filters, etc. Remember, you inhale or ingest the filth that collects on the cigarette from dirty hands. Save your smoking time for lunch hours or at home.

3. Never put your hands above your collar when working on any plant equipment, if possible.

4. Don't wear your overalls or rubber boots to the dining area.

5. Always wear your rubber boots when working in tanks, around sludge, washing down, etc. Don't wear your street shoes.

6. Keep your street shoes in your locker. Remember: what your shoes pick up at the plant they will leave on the floor of your home.

7. Don't wear your coveralls or rubber boots in your car or home.

8. Have a complete change of clothing to wear when going home.

9. Always clean any equipment such as safety belts, harness, face masks, gloves, etc., after using. You or someone else may want to use it again.

10. Always wear rubber or plastic coated gloves when cleaning out pumps, handling hoses, or when working around the plant.

11. Avoid putting on gloves when your hands are dirty. Wash first.

12. Wash with plenty of water or take a shower immediately after being splashed with sludge, or any chemical. *DON'T DELAY.*

13. Don't just wash your hands before going home. Wash your face thoroughly too. There is more of your face to carry germs than there is of your hands.

14. Wear a hat when working around sludge tanks, filters, or cleaning out grit or other channels. Don't go home with your head resembling a mop that just wiped up the floor around a cleaned out pump.

15. Keep your fingernails cut short and clean - they are excellent carrying places for dirt and germs.

APPENDIX D

chlorine dosages for the treatment of water

PURPOSE OF CHLORINATION	DOSAGE IN PPM[1]	CONTACT TIME IN MINUTES	RECOMMENDED RESIDUAL TYPE	PPM
Disinfection: With Combined Residual[2]	1.0-5.0	Requirements determined by local health authorities		
Disinfection: With Free Residual[3]	1.0-10.0			
Ammonia (NH_3-N) Removal	10xNH_3-N content	20+	Free	0.1
Taste & Odor Control	10xNH_3-N content plus 1-5 ppm	20+	Free	1.0
Hydrogen Sulfide (H_2S) Removal	2.22xS content to free sulfur 8.9xS content to sulfate	Instantaneous	Free or combined	0.1
Iron (Fe) Removal[4]	0.64xFe content	Instantaneous	Combined	0.1
Manganese (Mn) Removal[4]	1.3xMn content	Variable	Free	0.5
Red Water Prevention	Maintain a free residual in dead ends	Variable	Free	0.1
COLOR REDUCTION	1.0-10.0	15	Free or combined	0.1
Algae Control	1.0-10.0	Variable	Free	0.5+
Slime Control	1.0-10.0	Residual needed throughout system	Free	0.5+
Control of Iron and Sulfur Bacteria	1.0-10.0		Free	1.0+
Coagulation Aid for Preparation of: Activated Silica	1.56 lb. per gal. 41 Baumé Na_2SiO_3	Not Applicable		
Coagulation Aid for Preparation of: Chlorinated Copperas	1 part per 7.8 parts $FeSO_4 \cdot 7H_2O$			

(1) Ppm means parts per million. 1 ppm = 8.34 lb per million gallons.

(2) Combined residual means the residual produced by the reaction of chlorine with the natural or added ammonia, or with certain organic nitrogen compounds.

(3) Free residual means the residual produced after the destruction with chlorine of ammonia, or of certain organic nitrogen compounds.

(4) Filtration is also required.

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chlorine dosages for the treatment of sewage

PURPOSE OF CHLORINATION	DOSAGE IN PPM[1]	RECOMMENDED RESIDUAL IN PPM[2]
Disinfection of:		
Fresh Raw Sewage	6-12	Requirements usually determined by local health authorities or state regulations.
Septic Raw Sewage	12-25	
Fresh Settled Sewage	5-10	
Septic Settled Sewage	12-40	
Chemical Precipitation Effluent	3-10	
Trickling Filter Effluent	3-10	
Activated Sludge Effluent	2-8	
Sand Filter Effluent	1-5	
Odor Control:		
Up Sewer	1.5-10	0
At Plant	5-10	0
Activated Sludge Operation:		
Sludge Bulking Control	2-8	0
Sludge Thickening	Variable	1.0
Trickling Filter Operation:		
Odor Control	2-6	0
Filter Pooling	5-40	1.0-2.0
Filter Fly Control	3-10	0.1
B.O.D. Reduction	6-12	0.2-0.5
Imhoff Tank Foaming	3-15	0
Digestor Supernatant	20-80	0-trace

[1] Ppm means parts per million. 1 ppm = 8.34 lb per million gallons.
[2] No contact time required except for disinfection where time is usually regulated by local health authorities or state regulations. Figures are for combined residuals.

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chlorine dosages for the treatment of swimming pool water

The chlorine dosage requirements of swimming pool waters are dependent on the type and magnitude of the chlorine residual required. This is usually governed by regulatory health authorities.

The conditions which affect the chlorine requirements include continuity of recirculation, rate of recirculation, efficiency of filtration, the number and location of the pool inlets for filtered water, the bathing load, the type and shape of the pool, the type of chlorine residual produced, pH and alkalinity.

The dosage rate can be based either on pool capacity or on the recirculation rate. Both methods of calculation are used very extensively.

The recirculation rate can be obtained by noting the pump capacity or by multiplying the capacity of the pool by 3, where the turn-over rate is three times in 24 hours; or by 4, where the turn-over rate is four times in 24 hours; or by any other turn-over rate that may be in use in any particular instance.

The usual chlorine dosages, unless otherwise directed by local health regulations, are as follows:

TYPE OF POOL	CHLORINE APPLICATION BASED ON RECIRCULATION RATE*	
	Average Minimum	Average Maximum
Indoor	2.0 p p m	5.0 p p m
Outdoor	3.0 p p m	10.0 p p m

* ppm means parts per million. 1 ppm = 8.34 lb per million gallons.

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APPENDIX E

DEFINITIONS

The following are the terms with their definitions normally associated with chlorination:

1. Chlorination
2. Superchlorination
3. Dechlorination
4. Hypochlorination
5. Gas chlorination
6. Prechlorination
7. Postchlorination
8. Marginal chlorination
9. Breakpoint chlorination
10. Disinfection
11. Sterilization
12. Chlorine demand
13. Chlorine residual
14. Free chlorine residual
15. Combined chlorine residual
16. Total chlorine residual
17. Free residual chlorination
18. Chloramines
19. Oxidation - in terms of taste and odour
20. Parts per million

DEFINITIONS

1. CHLORINATION

The application of a chlorine solution to a water supply or wastewater stream for the principal purpose of reducing population of harmful disease causing bacteria to an acceptable level.

Refer to Bulletin 65-W-4 (see appendix) for details.

2. SUPERCHLORINATION

The application of chlorine dosages greatly in excess of those normally used for disinfection purposes.

3. DECHLORINATION

A deliberate treatment of water to remove excess residual chlorine. Normally done prior to sending water out into system.

4. HYPOCHLORINATION

The addition of hypochlorites, such as sodium or calcium hypochlorite, to the water or wastewater to be treated. It is added in solution form usually by means of a diaphragm positive displacement pump. Used where chlorine requirement is small or where gas cannot be fed (safety, lack of water pressure).

5. GAS CHLORINATION

Chlorine gas mixed with water to form solution to treat water or wastewater.

6. PRECHLORINATION

The application of chlorine to a water supply at the beginning of the treatment process.

7. POSTCHLORINATION

The addition of chlorine to water after turbidity removal.

8. MARGINAL CHLORINATION

The addition of chlorine to water or wastewater to produce a total chlorine residual in the range of 0.2 to 0.5 mg/l.

9. BREAKPOINT CHLORINATION

Point at which near complete oxidation of chloramines and other chlorine combination is reached. Any residual beyond breakpoint is mostly free available chlorine.

10. DISINFECTION

The reduction of harmful bacterial populations as defined by the Ontario Ministry of the Environment drinking objectives.

11. STERILIZATION

Total destruction of bacterial populations.
We never sterilize in the water or wastewater industry.

12. CHLORINE DEMAND

The difference between the amount of chlorine added to water or wastewater and the amount of chlorine residual remaining at the end of a specified contact period.

13. CHLORINE RESIDUAL

Chlorine remaining in water or wastewater at the end of a specified contact period as combined or free chlorine. The chlorine residual for any given water varies with the amount of chlorine applied, time of contact, temperature, pH and the amount of chemical and organic contaminants in the water.

14. FREE CHLORINE RESIDUAL

Amount of chlorine available as hypochlorous acid or hypochlorite ion that is not combined with ammonia or other organic amines. It is much more powerful than combined chlorine residual.

15. COMBINED CHLORINE RESIDUAL

The chlorine in water in chemical combination with primarily ammonia or other nitrogenous compounds. Combined chlorine residual is measured by taking the difference between Total and Free chlorine residuals.

16. TOTAL CHLORINE RESIDUAL

Summation of free chlorine residual and combined chlorine residual.

17. FREE RESIDUAL CHLORINATION

The addition of chlorine to water until the requirements of ammonia and nitrogenous compounds are met plus a slight excess.

NOTE: This excess will then be in the form of hypochlorous acid which will attack and destroy the chlorinated ammonia and protein substances formed by the initial dose of chlorine. All the resulting residual will consist of 90% or better hypochlorous acid.

Free residual chlorination is particularly useful where large numbers of bacteria must be killed in a chemically contamined water. It has been clearly demonstrated that it will also inactivate the viruses. This system of chlorination is also noted for colour removal and is effective for the reduction of taste and odours in a raw water supply.

18. CHLORAMINES

Compounds of organic or inorganic nitrogen and chlorine. The reaction of free available chlorine with ammonia and many organic amines to form chloramines, principally monochloramine and dichloramine.

19. OXIDATION - IN TERMS OF TASTE AND ODOUR PROBLEMS

A chemical breakdown of complex organic compounds used in connection with the destruction of tastes and odours in water.

20. PARTS PER MILLION

Parts per million (ppm) and milligrams per litre (mg/l) are commonly used terms for expressing concentration in water and wastewater operations. It is a measure of a very small amount of a substance in a very large amount of water. Ppm and mg/l are the same and can be used interchangeably, or

$$1 \ mg/l = 1 \ ppm$$

In chlorination practice an operator should be able to calculate the average chlorine dosage in ppm given the

amount of water chlorinated during the same period of time. This period of time may be the instantaneous chlorine reading on the chlorinator and the instantaneous water meter reading, or as is more frequently the case the amount of chlorine fed for a 24-hour period (based on weigh scale readings) and the water pumpage during the same 24-hour period.

Example: At 8:00 a.m. on Tuesday the chlorine cylinder scale indicated 232 lbs. and the water meter read 78,343,000 Imp. gals. At 8:00 a.m. on Wednesday the chlorine cylinder scale indicated 169 lbs. and the water meter read 85,763,000 Imp. gals. What was the average chlorine dosage in ppm during this 24-hour period?

Chlorine used during 24-hour period = 232-169 = 63 lbs.
Water treated during same period

85,763,000-78,343,000 = 7,420,000 gals.

Average chlorine dosage:

$$\frac{63 \text{ lbs. (chlorine)} \times 1{,}000{,}000}{7{,}420{,}000 \text{ Imp. gals. (water)} \times 10 \text{ (factor to convert gals. to lbs.)}} = 0.85 \text{ ppm}$$

A simple formula to remember:

$$\boxed{\frac{C}{W \times 10} \times 1{,}000{,}000 = \text{ppm}}$$

Replace C with No. of lbs. of chlorine
Replace W with No. of Imp. gals of water.
Remember use the same time period for both.